# ELEMENTS OF
# OPTICAL MINERALOGY

# ELEMENTS OF
# OPTICAL MINERALOGY

## AN INTRODUCTION TO
## MICROSCOPIC PETROGRAPHY

BY

ALEXANDER N. WINCHELL, Doct. Univ. Paris
*Professor of Mineralogy and Petrology, University of Wisconsin*

SECOND EDITION, SECOND PRINTING

PART III. DETERMINATIVE TABLES

WITH A COLORED CHART AND TWO DIAGRAMS

NEW YORK
JOHN WILEY & SONS, INC.
LONDON: CHAPMAN & HALL, LIMITED
1939

PRINTED IN U. S. A.

PRESS OF
BRAUNWORTH & CO., INC.
BUILDERS OF BOOKS
BRIDGEPORT, CONN.

# PREFACE TO THE SECOND EDITION
## SECOND PRINTING

During the ten years since the publication of the second edition of these tables many new minerals have been described. About fifty of these are included in the third edition of Part II, which was published in 1933, while nearly seventy are of more recent date. The author has attempted to include in supplementary tables in this printing all the new minerals which seem to be well established and adequately described as to their optical properties. Unfortunately it has not been feasible to incorporate them in the main tables, but this is probably not a very serious difficulty since the minerals in question are all very rare.

It is hoped that the use of colored paper for the table (III) classifying minerals on the basis of their color (and pleochroism) in thin section will make it easy to find the various tables quickly and conveniently.

In the preparation of this printing the author has benefited by the assistance and encouragement of his wife, Florence S. Winchell.

Alexander N. Winchell

Madison, Wisconsin
March, 1939

# PREFACE TO THE SECOND EDITION

Of course tables prepared for the determination of minerals by optical methods should be based on the chief optical properties of the minerals. However, it is not at all obvious just which optical property should be used first in classifying the minerals. After several attempts to combine the most important properties in one table so that more than one of them could be used first, it seemed wiser to simplify the arrangement by making separate tables for each important property. In addition to the tables which are given, tables might be prepared based primarily upon the optic angle, optic sign, or extinction angles. However, the practical groups based upon optic angle or optic sign are too few in number to be satisfactory, while extinction angles are almost useless in distinguishing between tetragonal, hexagonal and orthorhombic minerals. Thus it comes about that the chief tables which are given are based upon refringence, or birefringence, or color (and pleochroism). As the dispersion methods of determining minerals come into wider use the table based upon dispersion will become more complete and more useful.

It is a pleasure to acknowledge that these tables have been improved as a result of thoughtful constructive criticism of the first draft by Professor F. F. Grout of the University of Minnesota; the writer has also had the advantage of an opportunity to examine copies of determinative mineral tables prepared by Professor Grout and others prepared by Professor D. J. Fisher of the University of Chicago. He has also benefited notably by frequent consultations with Professor R. C. Emmons of the University of Wisconsin.

Plate II, based on refringence and birefringence, has been prepared along lines suggested by Professor C. O. Swanson of the Michigan College of Mines and Professor R. H. B. Jones of the State College of Washington.

ALEXANDER N. WINCHELL.

MADISON, WISCONSIN,
January, 1929

# CONTENTS

# ILLUSTRATIONS

(In Pocket at Back)

## ABBREVIATIONS USED IN THE TABLES

**(Miller symbols and chemical formulas need no explanation here)**

*a* = front and rear crystal axis.
Abn. = abnormal
Abs. = absorption
Acic. = acicular
Alter. = alteration
Ang. = angle
Aniso. = anisotropic
Antim. = antimonate
Arsen. = arsenate

*b* = right and left crystal axis
Biax. = biaxial
Biref. = birefringence
Bl. = blue
Bor. = borate
Br. = brown
Bx. = bisectrix

*c* = vertical crystal axis
Carb. = carbonate
Chem. = chemical (nature or composition)
Chrom. = chromate
Cin. = cinnamon
Cl. = cleavage
Cleav. = cleavage
Col. = color
Coll. = colloidal
Colum. = columbate
Comp. = complex
Conch. = conchoidal
Cont. = continued
Cub. = cubic
Cryst. = crystal

Dec. = decomposed by
Decrep. = decrepitates
Deliques. = deliquescent
Disp. = dispersion
Dist. = distinct
Dodec. = dodecahedral
Dom. = domatic

Efferv. = effervesces (with acid)
El. = elongation
Elong. = elongation
Eq. = equant
Ext. = extinction
Extr. = extreme

Fib. = fibrous or fibers
Frac. = fracture

G. = specific gravity
Gel. = gelatinizes with
Gr. = green
Gran. = granular

H. = hardness
Hal. = halide
Hex. = hexagonal
Hygro. = hygroscopic

Ign. = igneous
Incl. = inclusions
Insol. = insoluble
Int. = interference
Is. = isometric
Isom. = isometric
Isotr. = isotropic

Lam. = lamellar
Lg. = large

Mass. = massive
Max. = maximum
Mod. = moderate
Molyb. = molybdate
Mon. = monoclinic

N = index of refraction
$N_e$ = index of refraction for the extraordinary ray
$N_g$ = greatest index of refraction
$N_m$ = mean index of refraction
$N_o$ = index of refraction for the ordinary ray

| | |
|---|---|
| $N_p$ | = least index of refraction |
| Nit. | = nitrate |
| Oct. | = octahedral |
| Opt. | = optic |
| Or. | = orientation |
| Orth. | = orthorhombic |
| Ox. | = oxide |
| Oxal. | = oxalate |
| Part. | = parting |
| Perf. | = perfect |
| Phos. | = phosphate |
| Pinac. | = pinacoidal |
| Pleo. | = pleochroic or pleochroism |
| Prism. | = prismatic |
| Pneumat. | = pneumatolytic |
| Pt. | = parting |
| Ps. | = pseudo. |
| Pyr. | = pyramidal |
| Rh. | = rhombohedral |
| Rhom. | = rhombohedral |
| Sel. | = selenate |
| Sil. | = silicate |
| Skel. | = skeleton |
| Sm. | = small |
| Sol. | = soluble in |
| Str. | = strong |
| Sul. | = sulphate |
| Syst. | = system |
| Tab. | = tabular |
| Tant. | = tantalate |
| Tel. | = tellurate |
| Tet. | = tetragonal |
| Tetar. | = tetartohedral |
| Tet'h. | = tetrahedral |
| Tit. | = titanate |
| Tr. | = triclinic. |
| Trap. | = trapezohedral |
| Tung. | = tungstate |
| Twin. | = twinning |
| V | = half of true optic angle |
| Van. | = vanadate |
| Var. | = variable |
| Vit. | = vitreous |
| X | = vibration dircetion of the fast ray |
| Y | = vibration direction of the intermediate ray |
| Yel. | = yellow |
| Z | = vibration direction of the slow ray |
| $>$ | = greater than |
| $\geq$ | = greater than or equal to |
| $<$ | = less than |
| $\wedge$ | = angle between |
| $\perp$ | = normal to |
| $\parallel$ | = parallel to |
| $\pm$ | = plus or minus (or nearly) |

The sign of the extinction angle in monoclinic minerals is positive when it is measured in the obtuse angle between $a$ and $c$ and negative when it is measured in the acute angle $\beta$.

# OPTICAL MINERALOGY

## Part III

## INTRODUCTION

### DETERMINATIVE TABLES

In order to use determinative tables based on optical properties successfully the worker must be familiar with optical principles and the methods of applying them to the measurement or estimation of the optical properties of minerals; these topics are discussed in Part I of this work.

The following tables are as complete as available data permit so far as transparent or translucent minerals are concerned. Only a few of the commoner opaque minerals are included, because the ordinary petrographic methods are not well adapted for the study of such minerals.

In general, the tables summarize the data for the minerals described in Part II of this work. In some cases minerals are described somewhat incompletely in Part II and this condition may lead to their necessary omission from one or more of the tables composing (this) Part III. In a few other cases, data, published since the appearance of Part II, have been used in the tables. The tables include all natural minerals whose optic properties are known.

The first of the following tables deals with the common opaque minerals; so far as these are always opaque in standard thin sections they are not included in the other tables. Those minerals which are sometimes opaque and sometimes translucent in thin section are included in this first table and also in the other tables, so far as available data regarding them permit.

The second table which follows is based primarily upon the birefringence of minerals and secondarily upon their refringence. In order to use this property of refringence with more precision the following scale has been adopted:

## SCALE OF REFRINGENCE

1. Fluorite, N = 1.434. Negative distinct. N < 1.48.
   Limit: Natrolite, $N_m$ = 1.48±. Castor oil, N = 1.48±.

2. Leucite, N = 1.509. Negative low. N > 1.48 < 1.54.

| | | |
|---|---|---|
| Limit: | Microcline, $N_g$ = 1.529. | Clove oil, N = 1.531–1.533. |
| | | Fennel oil, N = 1.54. |
| | Quartz, $N_o$ = 1.544. | Canada balsam, N = 1.533–1.541. |

3. Labradorite, $N_m$ = 1.557–1.567. Positive low. N > 1.53 < 1.59.
   Limit: Muscovite, $N_m$ = 1.59±. Bromoform, N = 1.589.

4. Apatite, $N_o$ = 1.634. Positive moderate. N > 1.59 < 1.66.
   Limit: Enstatite, $N_m$ = 1.66±. $\alpha$-Monobromnaphthalene, N = 1.65–1.66.

5. Augite, $N_m$ = 1.71±. Positive high. N > 1.66 < 1.74.
   Limit: Staurolite, $N_m$ = 1.741–1.753. Methylene iodide, N = 1.742.

6. Zircon, $N_g$ = 1.93–1.96. Positive very high. N > 1.74 < 2.00.
   Limit: Zincite, $N_o$ = 2.008. Amorphous sulphur, N= 1.998.

7. Rutile, $N_g$ = 2.61±. Positive extreme. N > 2.00.

Whenever an unknown mineral is in contact with any of the minerals or liquids which form the limits of this scale of refringence, so that a direct comparison of indices can be made by the method of vertical or inclined illumination, an accurate classification is possible even if the differences in the indices are very slight. For this purpose not only are the minerals and liquids named above available, but other common minerals and liquids which are near these limits may be used. The following table may be useful in this connection:

## COMMON MINERALS NEAR THE LIMITS OF THE SCALE OF REFRINGENCE

Between 1 (negative distinct) and 2 (negative low):

| | | | |
|---|---|---|---|
| Natrolite | N = 1.48± | Cristobalite | N = 1.486 |
| Chabazite | $N_m$ = 1.48± | Analcite | N = 1.487 |
| Gmelinite | $N_m$ = 1.48± | Borax | $N_g$ = 1.472 |
| Sodalite | N = 1.483–1.487 | Tridymite | $N_g$ = 1.473 |

Between 2 (negative low) and 3 (positive low):

| | | | |
|---|---|---|---|
| Microcline | $N_g$ = 1.529 | Quartz | $N_o$ = 1.544 |
| Orthoclase | $N_g$ = 1.526 | Oligoclase | $N_m$ = 1.543 |
| Gypsum | $N_g$ = 1.530 | Chalcedony | $N_m$ = 1.537 |
| Albite | $N_m$ = 1.529 | Nephelite | $N_o$ = 1.536–1.547 |
| Anorthoclase | $N_m$ = 1.529 | Cordierite | $N_m$ = 1.543± |

Between 3 (positive low) and 4 (positive moderate):

| | | | |
|---|---|---|---|
| Muscovite | $N_g = 1.59\pm$ | Anorthite | $N_g = 1.585\pm$ |
| Chlorite | $N_m = 1.57\text{–}1.62+$ | Beryl | $N_o = 1.58\text{–}1.60$ |
| Talc | $N_m = 1.58\text{–}1.59$ | Scapolite ($Ma_{25}Me_{75}$) | $N_o = 1.59\pm$ |

Between 4 (positive moderate) and 5 (positive high):

| | | | |
|---|---|---|---|
| Enstatite | $N_m = 1.66$ | Forsterite | $N_m = 1.66$ |
| Calcite | $N_o = 1.6585$ | Gehlenite | $N_e = 1.658$ |
| Sillimanite | $N_m = 1.66\pm$ | Spodumene | $N_p = 1.65\text{–}1.67$ |
| Tourmaline | $N_o = 1.668$ (average) 1.65–1.67 (blue and green) | | |

Between 5 (positive high) and 6 (positive very high):

| | | | |
|---|---|---|---|
| Staurolite | $N_m = 1.74\text{–}1.75$ | Chloritoid | $N_m = 1.74\pm$ |
| Grossularite | $N = 1.735$ | Rhodonite | $N = 1.73\text{–}1.76$ |
| Hedenbergite | $N_m = 1.737$ | Augite | $N_g = 1.71\text{–}1.73$ |
| Epidote (of moderate birefringence) | $N_m = 1.74$ 1.75. | | |

Between 6 (positive high) and 7 (positive extreme):

| | | | |
|---|---|---|---|
| Zincite | $N_o = 2.008$ | Titanite | $N_g = 2.01\pm$ |
| Cassiterite | $N_o = 1.997$ | Sulphur | $N_m = 2.038$ |
| Schorlomite | $N = 1.95\text{–}2.01$ | Picotite | $N = 2.05\pm$ |

It is evident that an unknown mineral will not be found in contact with all these limit minerals. However, in thin sections, the unknown mineral is always immersed in Canada balsam, and the index of this substance is therefore commonly taken as a standard. If a mineral has a lower index than balsam its relief (and refringence) may be said to be negative, and, if higher, positive. Unfortunately balsam is rarely pure and therefore its index is not invariable; actual measurements have shown that it rarely passes the limits, 1.533 and 1.541; but, in order to be on the safe side, the tables include in the division of "negative low relief" minerals of indices up to 1.544 (= $N_o$ in quartz), and in the division of "positive low relief" minerals of indices as low as 1.529 (= $N_g$ in microcline). Even then there may be difficulty with sections prepared in the last few years since balsam dissolved in xylol has come into use, because such balsam may have an index less than that of orthoclase, perhaps even below 1.520. Therefore it is desirable to check the index of the balsam by a comparison with that of known minerals, especially potash feldspar.

It is believed that minerals can be classed accurately in this scale whenever they belong near the middle of one of the divisions, simply by comparing the relief of the unknown mineral with that of the various type minerals selected or with that of the minerals selected as limits. For this purpose the type minerals or the limit minerals may be sought in sections already available, or, more conveniently, the

type minerals or the limit minerals may all be mounted with the proper orientation to show the indices desired on a single slide. Such a slide would then serve as a standard for comparisons. When unknown minerals belong near a limit between two divisions of the scale of refringence a comparison of the relief is not sufficient to classify them accurately, and, if the unknown mineral is not in contact with a limit mineral (or substitute), and cannot be tested with a liquid, it may be necessary to assume that the mineral may belong in either one of the two divisions concerned.

So far as the refringence is concerned minerals are classified in the tables on the basis of N, $N_o$, or $N_m$. That is, the single index, N is used if the mineral is isotropic, the index of the ordinary ray, $N_o$, is used if the mineral is uniaxial, and the intermediate index, $N_m$, is used if the mineral is biaxial. This can lead to no difficulties with isotropic minerals. If the mineral is uniaxial, every grain or anhedron, in whatever position it may be, can be made to give the relief due to $N_o$ simply by turning the stage to that position of extinction at which the vibration direction of the ordinary ray in the mineral coincides with the vibration direction of the lower nicol. Any position of a basal section may be used. If the mineral is biaxial every grain or anhedron has two indices of refraction; $N_g'$ and $N_p'$, such that $N_g' \geq N_m \geq N_p'$. That is, one index is always greater than, or equal to, $N_m$, and the other is always equal to, or less than, $N_m$. Every section or grain normal to an optic axis, and therefore having minimum birefringence, has two equal indices of refraction which are each equal to $N_m$. Any section or grain normal to a bisectrix or merely normal to the optic plane can be used to obtain $N_m$ accurately, since it is only necessary to turn the mineral until the direction normal to the optic plane is parallel with the vibration direction of the lower nicol. Therefore, it is always possible to estimate, at least approximately, the value of $N_m$ for an unknown biaxial mineral. If the birefringence of the unknown mineral is not great the relief of any grain or section in any position is sufficient to give a close approximation to the value of $N_m$; if the birefringence is strong or extreme it is important to study the relief in each extinction position, and on several grains or anhedra.

However, the most important advantage of using N, $N_o$ and $N_m$ in the tables is that their use makes it possible to estimate the refringence correctly without any preliminary study as to biaxial or uniaxial character. It is only necessary to select that grain or section which

shows the minimum interference color in order to obtain from it in any position the index which is used in the tables.

Of course, all minerals whose index of refraction varies (usually because of variation in composition) are entered in the tables in as many places as necessary to express the complete range of variation.

The main divisions in the table are based on the birefringence. For convenience in the use of this character the following scale has been employed.

SCALE OF BIREFRINGENCE

| No. Mineral | Birefringence | | Max. interf. colors in sections 0.03 mm. thick | |
|---|---|---|---|---|
| 1. Leucite. | Very weak. | $N_g-N_p < 0.0035$. | Dark grays. | |
| 2. Orthoclase. | Weak. | $N_g-N_p > 0.0035 < 0.0095$. | Gray and white | First order |
| 3. Hypersthene. | Moderate. | $N_g-N_p > 0.0095 < 0.0185$. | Yellow and red | |
| 4. Augite. | Rather strong. | $N_g-N_p > 0.0185 < 0.0275$. | Blue and green | Second order |
| 5. Tourmaline. | Strong. | $N_g-N_p > 0.0275 < 0.0365$. | Yellow and red | |
| 6. Muscovite. | Very strong. | $N_g-N_p > 0.0365 < 0.0545$. | Blue to red. | Third order |
| 7. Titanite. | Extreme. | $N_g-N_p > 0.0545$. | Greenish and violet grays. | Higher orders |

Since all anisotropic minerals may be oriented so as to give the lowest interference colors, only the *maximum* birefringence is a property of determinative value, and it is necessary to assume that the maximum interference color can be obtained from the given unknown mineral (or, at least, a color near the maximum). In the case of minerals whose (maximum) birefringence varies with variation in composition, as in hornblende and epidote, the names are entered in as many subdivisions as necessary to express the complete range of variation.

The second table is based primarily upon birefringence and secondarily upon refringence. The fifty six groups thus established are subdivided still further on the basis of color and crystallization for the groups dealing with isotropic minerals and on the basis of optic sign, cleavages, elongation, extinction directions with respect to elongation or cleavages and color. For the purposes of this table cleavages are not considered to be "visible" unless they are described as "perfect" or are known to be readily observed in thin section. Thus, the "distinct" cleavage of olivine is so difficult of observation in thin section that it is not considered "visible."

The third table which follows, like the second, is designed primarily for use in connection with the study of thin sections. It is based,

first, on the color and pleochroism of minerals in thin sections, and secondarily upon the birefringence. In each subdivision, thus formed, the minerals are arranged in the order of increasing refringence. Of course, minerals vary in color; they are entered in the table in as many places as necessary to express all these variations, so far as known; but too much reliance should not be put on color alone as a means of identifying minerals. The table may, nevertheless, be useful as a means of suggesting possibilities in many cases.

The fourth and fifth tables are designed primarily for use with powders and immersion liquids, though the fourth table can also be used to good advantage under favorable circumstances in the study of thin sections. The fourth table is based primarily upon the refringence of minerals. It is divided into two parts, the first one including the isotropic minerals and the second one including the anisotropic minerals. In each part the minerals are arranged in the order of increasing refringence and all known variations in refringence are shown by means of vertical lines at the right of the column of indices. In the second part of the table positive minerals are distinguished from negative ones by indenting the indices of refraction of negative minerals two spaces to the right.

The fifth table is based primarily on the dispersion of minerals, that is, on the difference in index of refraction (N, $N_o$ or $N_m$) in light of the *F* line wave-length and light of the *C* line wave-length. In each group, thus established, the minerals are arranged in the order of increasing refringence. This table is intended for use with powdered minerals and immersion liquids. It presents all available data, but is remarkably incomplete.

Neither the relative abundance nor the relative importance of minerals can be measured quantitatively; both are matters of estimate and vary with time and place. Nevertheless, minerals vary so greatly in these respects that it seems worth while to express this variation, even though the expression be only the author's estimate of the condition. For this purpose the names of minerals in the tables are set in different styles of type, as follows:

1. Bold-face capital letters are used for very common minerals, like quartz, calcite and orthoclase, and also for a few very important minerals like nephelite.

2. Bold-face lower case letters are used for common minerals, like tremolite, rutile, tourmaline, etc., and also for a few important minerals, like analcite, andalusite and cordierite.

3. Ordinary Roman type is used for less common minerals, like chabazite, humite and pectolite, and also for minerals quite abundant or important in rare rocks, ores and other unusual mineral aggregates, such as aegirite, arsenopyrite, diamond, galena, halite, malachite, etc.

4. Italic type is used for many very rare minerals, such as agricolite, cervantite and hillebrandite.

## TABLE I.—OPAQUE MINERALS

The petrographic microscope is not well adapted to the study of minerals which are opaque in thin section; therefore only those few of the commonest opaque minerals are included in the following table which were included in Part II of this work. No one working with the petrographic microscope should expect to identify an opaque mineral with certainty unless it has a *characteristic* color in reflected light, a condition which is quite rare. Nevertheless, the commoner opaque minerals can be recognized with a high degree of probability in many cases, and the table of opaque minerals will assist in this work. For accurate study of opaque minerals special mineragraphic microscopes should be used and the samples should not be mounted in thin sections, but very highly polished on one uncovered side. For more complete directions for such work reference may be made to the works of Murdoch, Davy and Farnham, Schneiderhöhn and van der Veen.

Minerals which are always opaque in thin sections are included in the following table, and, in general, not included in the other tables; minerals which are subtranslucent to opaque in thin section are included for convenience both in the following table and in the other tables, so far as known data permit.

The page references in the following table refer to the third edition of Part II of this work.

# TABLE I.—OPAQUE MINERALS

Minerals, Which Are Opaque because of Aggregate Effects, like Leucoxene, Some Limonite, Glauconite, etc., Are Not Included Here

1. Always opaque in thin sections of standard thickness

| Color in Reflected Light | Cleavage | System | Mineral | Chemical | Other Characters | Page |
|---|---|---|---|---|---|---|
| **Steel blue** | 111 part. | Isom. | **MAGNETITE** | $Fe_3O_4$ | Magnetic. Common | 63 |
| | None | Rhom. | **Ilmenite** | $FeTiO_3$ | Alters to leucoxene | 66 |
| | None | Rhom. | **HEMATITE** | $Fe_2O_3$ | Oxidation product | 44 |
| **Iron black to steel gray** | 111 part. | Isom. | *Franklinite* | Ox. | In rare ores | 63 |
| | None | Isom. | **Chromite** | $FeCr_2O_4$ | Oct. In ign. rocks | 62 |
| | 100 perf. | Isom. | *Iron* | Fe | Very magnetic. Rare | 16 |
| | ? | Isom. | *Ulrichite* | $UO_2$? | In veins and pegmatites | 68 |
| | ? | Isom. | *Metacinnabarite* | HgS | Unstable. Rare | 21 |
| | 001 dist. | Tet. | *Hausmannite* | $Mn_3O_4$ | In ores. Rare | 64 |
| | 111 perf. | Tet. | *Braunite* | $Mn_2O_3$ | In ores. Rare | 66 |
| | 0001 perf. | Hex. | Graphite | C | Very soft. Uncommon | 14 |
| | 100 dist. | Orth. | Columbite | Colum. | In pegmatite. Rare | 165 |
| | 110 perf. | Orth. | *Enargite* | $Cu_3AsS_4$ | In Cu ores. G.=4.4 | 28 |
| | 010 perf. | Mon. | Wolframite | Tung. | In veins and pegmatites | 101 |
| **Lead gray** | 100 perf. | Isom. | **Galena** | PbS | In veins, contacts, etc. | 19 |
| | None | Isom. | *Argentite* | $Ag_2S$ | In veins. Rare | 19 |
| | 0001 perf. | Hex. | Molybdenite | $MoS_2$ | In veins and pegmatites | 26 |
| | 001, 100 | Orth. | Chalcocite | $Cu_2S$ | In veins, etc. Rare | 18 |
| **Silver white** | 110 dist. | Orth. | Arsenopyrite | FeAsS | In veins, etc. Rare | 24 |
| **Silver white** | None | Isom. | *Silver* | Ag | In veins, etc. Rare | 16 |
| **Gold yellow** | None | Isom. | *Gold* | Au | In veins, placers, etc. | 16 |
| **Brass yellow** | None | Isom. | **Pyrite** | $FeS_2$ | G.=5. Widely distributed | 22 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Brass yellow, dark | None | Tet. | Chalcopyrite | $CuFeS_2$ | In veins, etc. | 26 |
| Bronze yellow | 0001 poor | Hex. | **Pyrrhotite** | $FeS$ | Magnetic. Not rare | 21 |
| Bronze yellow | 110 dist. | Orth. | Marcasite | $FeS_2$ | In coal, veins, etc. | 24 |
| Copper red | None | Isom. | *Copper* | $Cu$ | In veins, etc. Rare | 16 |
| Copper red, brownish | None | Isom. | *Bornite* | $Cu_5FeS_4$ | In veins, etc. Rare | 26 |
| Copper red, pale | None | Hex. | *Niccolite* | $NiAs$ | In veins, etc. Rare | 20 |
| Deep red | None | Rhom. | **HEMATITE** | $Fe_2O_3$ | Oxidation product | 44 |
| Indigo blue | 0001 perf. | Hex. | *Covellite* | $CuS$ | In veins, etc. Rare | 20 |

2. Subtranslucent to opaque in thin section. In reflected light most of the following minerals are steel gray; hematite is usually red, but specularite is like steel in reflected light

| Color in Transmitted Light | | | | | | |
|---|---|---|---|---|---|---|
| Red, cherry | None | Isom. | Tetrahedrite | $Cu_6Sb_2S_6$ | Splendent luster. Rare | 26 |
| Red, dark | None | Isom. | *Magnesioferrite* | $MgFe_2O_4$ | About volcanoes. Rare | 61 |
| Red, brownish | None | Isom. | **Chromite** | $FeCr_2O_4$ | Oct. In ign. rocks | 62 |
| Red, dark | 110 dist. | Tet. | **Rutile** | $TiO_2$ | Sparse, but not rare | 50 |
| Red, brownish | 001 perf. | Tet. | *Heterolite* | $ZnMn_2O_4$ | In ores. Rare | 65 |
| Red, blood | None | Rhom. | **HEMATITE** | $Fe_2O_3$ | Oxidation product | 44 |
| Red, dark | 010 perf. | Orth. | Stibnite | $Sb_2S_3$ | In veins, etc. Rare | 25 |
| Red, dark | 100 dist. | Orth. | *Tantalite* | Tant. | In pegmatites, etc. | 165 |
| Red, dark | 010 poor | Mon. | *Miargyrite* | $AgSbS_2$ | In veins, etc. Rare | 27 |
| Red, blood | None | Mon. ? | *Arizonite* | Ox. ? | In pegmatite. Rare | 68 |
| Brown | None | Tet. | *Plattnerite* | $PbO_2$ | In oxide zone of veins | 53 |
| | 001 dist. | Tet. | *Hausmannite* | $Mn_3O_4$ | In ores. Rare | 64 |
| | 010 poor | Orth. | *Samarskite* | Colum. | In pegmatites. Rare | 166 |
| | ? | Orth. | *Hjelmite* | Tant. | In pegmatites. Rare | 166 |
| Brown or green | 100 | Isom. | *Dysanalite* | Tit. | In contacts, etc. Rare | 163 |
| | 001, 010 | Orth. | Ilvaite | Sil. | In contacts, etc. Rare | 431 |
| | 001 perf. | Mon. | Cronstedtite | Sil. | In ores, etc. Not common | 285 |

# TABLE II.—BIREFRINGENCE OF MINERALS

In thin section it is usually possible to estimate the birefringence of any unknown mineral at least approximately by means of its maximum interference color and a measure or estimate of the thickness of the section. Therefore a determinative table based primarily on the birefringence is highly desirable. It is true that the chart of birefringences (Plate I) is based on the same property, but the colored chart shows only the rock-forming minerals and is therefore incomplete and unsatisfactory when studying ores and other uncommon mineral aggregates. Furthermore, the colored chart shows only the birefringence of minerals, while the following table of birefringence serves to identify the minerals also by means of their refringence, cleavage, color, crystal form, optic sign, optic angle, optic orientation, etc.

Many minerals vary more or less in their chemical composition and therefore in their physical properties, including their birefringence. Each mineral is entered in the tables in as many places as necessary to express all variations in its properties, so far as they are known.

For methods of estimating or measuring the birefringence of minerals, see the fifth edition of Part I, pages 116–124 and 135–137.

For methods of estimating or measuring the refringence of minerals, see Part I, pages 75–85 and (for minerals in powder form) pages 228–239 and 248–253.

For a discussion of cleavage, see Part I, pages 29–32. For the purposes of this table cleavages are not considered to be "visible" unless they are known to be observed readily in thin section or are described as "perfect."

For a discussion of color and absorption, see Part I, pages 55–56.

For methods of determining pleochroic formulas, see Part I, pages 170, 171, 204, and 211.

For definitions of X, Y and Z, see Part I, pages 117 and 160.

For methods of distinguishing between X, Y and Z, see Part I, pages 124, 130, 137, and 211.

For a discussion of crystal forms and crystal systems, see Part I, pages 2–26.

For methods of determining the optic sign, see Part I, pages 129–132, 138, 148–154, 169, and 206–213.

For methods of estimating or measuring the optic axial angle, see Part I, pages 186–189, 211, 226, and 245.

For methods of determining the optic orientation of a mineral, see Part I, pages 170, 171, 205, and 212.

For methods of measuring extinction angles, see Part I, pages 126, 137, 173, 174, and 178.

For a list of abbreviations and symbols used in the table see page xiii.

The last column in the table gives the page of the third edition of Part II of this work on which a more complete description of each mineral may be found.

Success in using the table is absolutely dependent upon accuracy in assigning an unknown mineral to the subdivision to which it belongs; therefore the following outline classification should be used with the utmost care.

| Birefringence. ($N_g-N_p$) | Optic Sign | Refringence ($N$, $N_o$ or $N_m$) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | <1.48 | >1.48 <1.54 | >1.53 <1.59 | >1.59 <1.66 | >1.66 <1.74 | >1.74 <2.00 | >2.00 |
| | | Group | Group | Group | Group | Group | Group | Group |
| 0.000 | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| <0.0035 | + | 8 | 9a | 10a | 11a | 12 | 13 | 14 |
| | − | | 9b | 10b | 11b | | | |
| >0.0035 <0.0095 | + | 15a | 16a | 17a | 18a | 19a | 20a | 21 |
| | − | 15b | 16b | 17b | 18b | 19b | 20b | |
| >0.0095 <0.0185 | + | 22a | 23a | 24a | 25a | 26a | 27a | 28a |
| | − | 22b | 23b | 24b | 25b | 26b | 27b | 28b |
| >0.0185 <0.0275 | + | 29a | 30a | 31a | 32a | 33a | 34a | 35a |
| | − | 29b | 30b | 31b | 32b | 33b | 34b | 35b |
| >0.0275 <0.0365 | + | 36 | 37a | 38a | 39a | 40a | 41a | 42 |
| | − | | 37b | 38b | 39b | 40b | 41b | |
| >0.0365 <0.0545 | + | 43 | 44a | 45a | 46a | 47a | 48a | 49a |
| | − | | 44b | 45b | 46b | 47b | 48b | 49b |
| >0.0545 | + | 50 | 51a | 52a | 53a | 54a | 55a | 56a |
| | − | | 51b | 52b | 53b | 54b | 55b | 56b |

# TABLE II.—BIREFRINGENCE OF MINERALS

## O. BIREFRINGENCE ZERO: $N_g - N_p = 0.000$

| Cleavage, Optic Orient. | Habit, etc. | Color | N | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 1.** Refringence negative and distinct: $N < 1.48$ | | | |
| | | | | A. Uncolored in thin section and not isometric | | | |
| None | Clay | Colorless | 1.40? | *Termierite* | Sil. | G.=1.2? Sol. HCl | 415 |
| None | Mass. | Colorless | 1.41–6 | **Opal** | Ox. | G.=2.1. Sol. HF or KOH | 57 |
| None | Vit. | Colorless | 1.458 | *Lechatelierite* | $SiO_2$ | G.=2.2. Sol. HF | 57 |
| None | Clay | Colorless | 1.47–9 | ***Allophane*** | Sil. | G.=1.87. Gel. HCl | 415 |
| None | Clay | Colorless | 1.47–1.57 | Halloysite | Sil. | G.=2.1. Sol. HF | 415 |
| | | | | B. Uncolored in thin section and isometric | | | |
| 111 perf. | Oct. | Colorless | 1.339 | *Hieratite* | Hal. | G.=2.75. Sol. $H_2O$ | 36 |
| 110 perf. | Oct. | Colorless | 1.339 | *Cryolithionite* | Hal. | G.=2.78. Sol. $H_2O$ | 34 |
| None | Oct. | Colorless | 1.427 | *Ralstonite* | Hal. | Also biref. with 2V=Lg. | 36 |
| 111 perf. | Cub. | Colorless | 1.434 | Fluorite | $CaF_2$ | G.=3.18. Sol. $H_2SO_4$ | 31 |
| 111 | Gran. | Colorless | 1.435–1.45 | *Yttrofluorite* | Hal. | Color fades in light | 35 |
| ? | Cub. | Colorless | 1.45–6 | *Melanophlogite* | $SiO_2$ | Black on heating | 54 |
| None | Dodec. | Colorless | 1.454 | ***Sulfohalite*** | Sul. | G.=2.5. Sol. $H_2O$ | 118 |
| None | Isom. | Colorless | 1.456 | Potassalumite | Sul. | G.=1.76. Sol. $H_2O$ | 113 |
| None | Fib. | Colorless | 1.457 | *Tschermigite* | Sul. | G.=1.64. Sol. $H_2O$ | 113 |
| 111 dist. | Oct. | Colorless | 1.48 | *Faujasite* | Sil. | Also biref. Gel. HCl | 382 |
| 001 diff. | Trap. | Colorless | 1.48–9 | **Analcite** | Sil. | Also biref. Gel. HCl | 293 |
| | | | | C. Colored in thin section | | | |
| 111 perf. | Cub. | Tinted ± | 1.434 | Fluorite | $CaF_2$ | G.=3.18. Sol. $H_2SO_4$ | 31 |
| 111 poor | Gran. | Violet | 1.435 | *Yttrocerite* | Hal. | G.=3.5. Sol. HCl | 36 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 111 | Gran. | Yel., gr. | 1.435–1.45 | *Yttrofluorite* | Hal. | Color fades in light | 35 |
| ? | Cub. | Yellow ± | 1.45–6 | *Melanophlogite* | $SiO_2$ | Black on heating | 54 |
| None | Mass. | Yel., br. | 1.45–7 | *Hisingerite* | Sil. | G. = 3. Dec. HCl | 415 |
| None | Mass. | Brown | 1.47? | *Neotocite* | Sil. | G. = 2.7. Dec. HCl | 413 |

**Group 2.** Refringence negative and low: $N > 1.48 < 1.54$

A. Uncolored in thin section and not isometric

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| None | Clay | Colorless | 1.47–9 | ***Allophane*** | Sil. | G. = 1.87. Gel. HCl | 415 |
| None | Conch. | Colorless | 1.485 | *Evansite* | Phos. | G. = 1.94. Sol. $H_2SO_4$ | 145 |
| None | Mass. | Colorless | 1.49+ | *Vashegyite* | Phos. | G. = 1.96. Sol. HCl | 144 |
| None | Mass. | Colorless | 1.50± | *Stevensite* | Sil. | Alter. of pectolite | 419 |
| None | Mass. | Colorless | 1.50± | *Montmorillonite* | Sil. | G. = 2.± | 434 |
| None | Mass. | Colorless | 1.517 | *β-Sepiolite* | Sil. | G. = 2. | 410 |
| None | Mass. | Colorless | 1.517 | *Planerite* | Phos. | G. = 2.65. Dec. HCl | 145 |
| None | Mass. | Colorless | 1.53 | *Kehoeite* | Phos. | G. = 2.34. Sol. HCl | 158 |
| None | Mass. | Colorless | 1.53± | *Spadaite* | Sil. | Pearly luster. Gel. HCl | 413 |

B. Uncolored in thin section and isometric

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 111 dist. | Oct. | Colorless | 1.48 | *Faujasite* | Sil. | Also biref. Gel. HCl | 382 |
| 100 diff. | Trap. | Colorless | 1.48–9 | **Analcite** | Sil. | Also biref. Gel. HCl | 293 |
| 100 poor | Dodec. | Colorless | 1.485 | **Sodalite** | Sil. | G. = 2.14–2.4. Gel. HCl | 289 |
| ? | Oct. | Colorless | 1.486 | *Metacristobalite* | $SiO_2$ | G. = 2.27. Sol. HF | 54 |
| 100 perf. | Cub. | Colorless | 1.49 | Sylvite | KCl | G. = 1.98. Sol. $H_2O$ | 30 |
| 100 poor | Trap. | Colorless | 1.508 | **LEUCITE** | Sil. | G = 2.47. Dec. HCl | 291 |
| None | Oct. | Colorless | 1.508 | *Tychite* | Sul. | G. = 2.5. Sol. HCl | 118 |
| None | Oct. | Colorless | 1.514 | *Northupite* | Carb. | Also biref. G. = 2.38 | 85 |
| None | Cub. | Colorless | 1.525 | *Pollucite* | Sil. | G. = 2.9. Dec. HCl | 293 |
| ? | Tetar. | Colorless | 1.535 | *Langbeinite* | Sul. | G = 2.83. Sol. $H_2O$ | 110 |

# TABLE II.—BIREFRINGENCE OF MINERALS

O. Birefringence zero: $N_g - N_p = 0.000$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | Color | N | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 2.** Refringence negative and low: $N > 1.48 < 1.54$—*continued* | | | |
| | | | | C. Colored in thin section | | | |
| 110 poor | Dodec. | Blue, etc. | 1.48–9 | Noselite | Sil. | G. = 2.3. Gel. HCl | 290 |
| 110 poor | Dodec. | Yel., bl., red | 1.485 | **Sodalite** | Sil. | G. = 2.14–2.4. Gel. HCl | 289 |
| 110 poor | Dodec. | Violet | 1.487 | Hackmanite | Sil. | G. = 2.4 Gel. HCl | 290 |
| 110 poor | Dodec. | Blue, etc. | 1.49–1.51 | Hauynite | Sil. | G = 2.4. Gel. HCl | 290 |
| 110 poor | Dodec. | Blue | 1.50± | Lazurite | Sil. | G. = 2.4. Gel. HCl | 290 |
| None | Coll. | Yellow | 1.5± | *Rosiéresite* | Phos. | G. = 2.2. Sol. $HNO_3$ | 145 |
| None | Coll. | Bl., br. | 1.525–1.55 | *Cornuite* | Sil. | G. = 2. Opaline. Sol. HCl | 413 |
| None | Coll. | Yellow | 1.53–4 | *Succinite* | C, H | G. = 1.07. Sol. alcohol | 89 |
| None | Mass. | Brown | 1.53–7 | *Neotocite* | Sil. | G. = 2.7. Dec. HCl | 413 |
| | | | | **Group 3.** Refringence positive and low: $N > 1.53 < 1.59$ | | | |
| | | | | A. Uncolored in thin section | | | |
| None | Mass. | Colorless | 1.53 | *Kehoeite* | Phos. | G. = 2.34. Sol. HCl | 158 |
| None | Mass. | Colorless | 1.53± | *Spadaite* | Sil. | Pearly luster. Gel. HCl | 413 |
| ? | Tet'h | Colorless | 1.535 | *Langbeinite* | Sil. | G. = 2.83. Sol. $H_2O$ | 110 |
| 100 perf. | Cub. | Colorless | 1.544 | Halite | Hal. | G. = 2.17. Sol. $H_2O$ | 29 |
| None | Mass. | Colorless | 1.55 | *Montmorillonite* | Sil. | G. = 2.± | 434 |
| None | Mass. | Colorless | 1.555 | *Collyrite* | Sil. | G. = 2.±. F. = 7. | 435 |
| None | Mass. | Colorless | 1.56–1.61 | Bauxite | Ox. | G. = 2.55. Sol. $H_2SO_4$ | 49 |
| ? | Tet'h. | Pink | 1.57 | *Manganolangbeinite* | Sul. | G. = 3. Sol. $H_2O$ | 110 |
| None | Mass. | Colorless | 1.57–1.62 | **Collophane** | Phos. | G. = 2.6–2.9. Sol. $HNO_3$ | 161 |
| None | Mass. | Colorless | 1.584 | *Schroetterite* | Sil. | G. = 2.± | 415 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 111 | Tet'h. | Colorless | 1.59± | *Zunyite* | Sil. | G.=2.87. Sol. HF | 414 |
| ? | Cub. | Colorless | 1.59 | *Kochite* | Sil. | G.=2.93 | 414 |

B. Colored in thin section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| None | Coll. | Bl. or br. | 1.525–1.55 | *Cornuite* | Sil. | G.=2. Opaline. Sol. HCl | 413 |
| None | Coll. | Yellow | 1.53–4 | *Succinite* | C, H | G.=1.07. Sol. alcohol | 89 |
| None | Mass. | Brown | 1.53–1.7 | **Allanite** | Sil. | G.=3.±. Gel. HCl | 316 |
| None | Coll. | Brown | 1.53–7 | *Neotocite* | Sil. | G.=2.7. Dec. HCl | 413 |
| 001 perf. | Lam. | Green | 1.55–1.68 | **Chlorite** | Sil. | G.=2.6–3.0. Dec. HCl | 276 |
| None | Mass. | Green | 1.56–1.61 | *Zaratite* | Carb. | G.=2.6±. Sol. HCl | 85 |
| None | Mass. | Brown | 1.57–1.67 | *Borickite* | Phos. | G.=2.7±. Sol. HCl | 157 |
| None | Mass. | Brown | 1.57± | *Hisingerite* | Sil. | G.=3. Dec. HCl | 415 |
| None | Mass. | Green | 1.59 | *Garnierite* | Sil. | G=2.5±. Dec HCl | 261 |

**Group 4.** Refringence positive and moderate: $N>1.59<1.66$

A. Uncolored in thin section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ? | Cub. | Colorless | 1.59 | *Kochite* | Sil. | G.=2.93 | 414 |
| None | Mass. | Colorless | 1.6–1.87 | *Stibiconite* | Ox. | G.=5.2±. Also biref. | 68 |
| 0001 dist. | Var. | Colorless | 1.607 | *Eudialite* | Sil. | Colored in mass. G.=3± | 417 |
| None | Mass. | Colorless | 1.62–1.70 | *Diadochite* | Sul. | Opaline | 121 |
| 111 poor | Cub. | Colorless | 1.642 | *Salammoniac* | $NH_4Cl$ | G.=1.53. Sol. $H_2O$ | 30 |

B. Yellow in thin section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| None | Mass. | Orange | 1.59± | *Hisingerite* | Sil. | G.=3. Dec. HCl | 415 |
| None | Mass. | Yellow | 1.61± | *Gummite* | Ox. | G.=4±. Sol. HCl | 68 |
| None | Mass. | Yellow± | 1.62–1.70 | *Diadochite* | Sul. | Opaline | 121 |
| None | Mass. | Yel., br. | 1.63–5 | *Griphite* | Phos. | G.=3.4. Sol. HCl | 155 |
| None | Mass. | Yellow | 1.64 | *Picite* | Phos. | G.=2.83 | 145 |
| None | Mass. | Yellow | 1.64± | *Lagonite* | Bor. | Earthy | 94 |
| None | 001 | Yellow± | 1.64 | *Homilite* | Sil. | Also biref. G.=3.3± | 424 |
| None | Mass. | Yel., gr. | 1.65 | *Greenalite* | Sil. | G.=2.8+. Sol. HCl | 413 |

## TABLE II.—BIREFRINGENCE OF MINERALS

O. BIREFRINGENCE ZERO: $N_g-N_p=0.000$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | Color | N | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 4.** Refringence positive and moderate: $N>1.59<1.66$—*continued* | | | |
| | | | | C. Brown in thin section | | | |
| None | Mass. | Brown | 1.53–1.7 | **Allanite** | Sil. | G.=3±. Gel. HCl | 316 |
| None | Mass. | Brown | 1.57–1.67 | *Borickite* | Phos. | G.=2.7±. Sol. HCl | 157 |
| None | Mass. | Brown | 1.59± | *Hisingerite* | Sil. | G.=3. Dec. HCl | 415 |
| None | Mass. | Br., yel. | 1.63–5 | *Griphite* | Phos. | G.=3.4. Sol. HCl | 155 |
| None | Mass. | Red-br. | 1.635 | *Pitticite* | Sul. | G.=2.2–2.5. Sol. HCl | 121 |
| None | Mass. | Br., gr. | 1.65 | *Greenalite* | Sil. | G.=2.8+. Sol. HCl | 413 |
| | | | | D. Green in thin section | | | |
| 001 perf. | Lam. | Green | 1.55–1.68 | **Chlorite** | Sil. | G.=2.6–3.0. Dec. HCl | 276 |
| None | Mass. | Green | 1.59 | *Garnierite* | Sil. | G.=2.5±. Dec. HCl | 261 |
| ? | Oct. | Green | 1.60± | *Voltaite* | Sul. | G.=2.75. Sol. HCl | 115 |
| None | Mass. | Gr., br. | 1.65 | *Greenalite* | Sil. | G.=2.8+. Sol. HCl | 413 |
| | | | | **Group 5.** Refringence positive and high: $N>1.66<1.74$ | | | |
| | | | | A. Uncolored in thin section | | | |
| None | Mass. | Colorless | 1.6–1.87 | *Stibiconite* | Ox. | G.=5.2±. Also biref. | 68 |
| None | Oct. | Colorless | 1.67± | *Hibschite* | Sil. | Also biref. G.=3. Sol. HCl | 429 |
| None | Dodec. | Colorless | 1.675 | *Plazolite* | Sil. | G.=3.1 | 183 |
| 111 poor | Tet'h. | Colorless | 1.694 | *Rhodizite* | Bor. | Also biref. G.=3.35 | 94 |
| None | Isom. | Tinted ± | 1.71+ | **Pyrope** | Sil. | G.=3.6±. Insol. | 178 |
| None | ? | Colorless | 1.727 | *Berzelite* | Arsen. | G.=4. Sol. $HNO_3$ | 122 |
| 111 poor | Oct. | Tinted ± | 1.73± | Spinel | Ox. | G.=3.6. Sol. $H_2SO_4$ | 62 |
| None | Dodec. | Colorless | 1.735+ | **Grossularite** | Sil. | G.=3.5±. Insol. | 180 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 perf. | Cub. | Colorless | 1.735± | *Perciclase* | MgO | G. = 3.65. Sol. HCl | 41 |
| None | Mass. | Colorless | 1.74± | *Pilbarite* | Ox. | G. = 4.6. Sol. HCl | 185 |
| | | | | B. Yellow, brown, or red in thin section | | | |
| None | Mass. | Brown | 1.53–1.7 | **Allanite** | Sil. | G. = 3±. Gel. HCl | 316 |
| None | Mass. | Brown | 1.57–1.67 | *Borickite* | Phos. | G. = 2.7±. Sol. HCl | 157 |
| 110 ? | Tet. | Yel., br. | 1.68–1.72 | *Thorite* | Ox. | Also biref. G. = 5± | 185 |
| 110 poor | Cub. | Yellow ± | 1.69 | *Pharmacosiderite* | Phos. | G. = 3.0. Sol. HCl | 143 |
| None | Orth. | Brown | 1.70 | *Polycrase* | Colum. | G. = 5.0. Dec. $H_2SO_4$ | 167 |
| None | Isom. | Br., red | 1.71± | **Pyrope** | Sil. | G. = 3.6±. Insol. | 178 |
| None | Mass. | Br., yel. | 1.72 | *Delvauxite* | Phos. | G. = 1.9±. Concretions | 145 |
| 111 poor | Oct. | Red, etc. | 1.73± | Spinel | Ox. | G. = 3.6. Sol. $H_2SO_4$ | 62 |
| None | Rhom. | Yel., br. | 1.73–1.76 | *Tritomite* | Sil. | G. = 4.3. Dec. HCl | 420 |
| None | Dodec. | Yel.-red | 1.735+ | **Grossularite** | Sil. | G. = 3.5±. Insol. | 180 |
| 111 poor | Tet'h | Pink | 1.737 | *Danalite* | Sil. | G. = 3.4. Gel. HCl | 291 |
| 111 poor | Tet'h. | Yellow | 1.739 | *Helvite* | Sil. | G. = 3.2. Gel. HCl | 291 |
| None | Rhom. | Yel.-br. | 1.74± | *Caryocerite* | Sil. | G. = 4.3. Dec. HCl | 420 |
| | | | | C. Green or blue in thin section | | | |
| 001 perf. | Lam. | Green | 1.55–1.68 | **Chlorite** | Sil. | G. = 2.6–3.0. Dec. HCl | 276 |
| 100 poor | Cub. | Green | 1.69 | *Pharmacosiderite* | Phos. | G. = 3.0. Sol. HCl | 143 |
| None | Isom. | Green | 1.725 | *Rowlandite* | Sil. | G. = 4.5. Gel. HCl | 420 |
| 111 poor | Oct. | Blue, green | 1.73± | Spinel | Ox. | G. = 3.6. Sol. $H_2SO_4$ | 62 |

**Group 6.** Refringence positive and very high: $N > 1.74 < 2.00$

A. Uncolored in thin section and not isometric

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| None | Mass. | Colorless | 1.6–1.87 | *Stibiconite* | Ox. | G. = 5.2. Also biref. | 68 |
| None | Mass. | Colorless | 1.74 | *Pilbarite* | Ox. | G. = 4.6. Sol. HCl | 185 |
| None | Tet. | Colorless | 1.77 | *Mackintoshite* | Ox. | G. = 5.4. Sol. HCl | 185 |
| None | Tet. | Colorless | 1.82–1.93 | Malacon | Ox. | G. = 4±. Dec. $H_2SO_4$ | 184 |
| None | Var. | Colorless | 1.88–2.06 | *Cervantite* | Ox. | G. = 4. Sol. HCl | 67 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### O. Birefringence zero: $N_g - N_p = 0.000$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | Color | N | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | **Group 6.** Refringence positive and very high: $N > 1.74 < 2.00$—*continued* | | | | |
| | | | B. Uncolored in thin section and isometric | | | | |
| 111 poor | Oct. | Tinted± | 1.74± | Spinel | Ox. | G.=3.6. Sol. $H_2SO_4$ | 62 |
| None | Dodec. | Tinted± | 1.74± | **Grossularite** | Sil. | G.=3.5±. Insol. | 180 |
| None | Oct. | Colorless | 1.755 | *Arsenolite* | $As_2O_3$ | G.=3.7. Sol. $H_2O$ | 43 |
| None | Oct. | Tinted± | 1.87± | *Chalcolamprite* | Colum. | G.=3.77. Insol. | 164 |
| None | Oct. | Tinted± | 1.92± | *Betafite* | Tit. | G.=4. Insol. | 164 |
| None | Oct. | Tinted± | 1.92–1.96 | *Samirésite* | Colum. | G.=5.24. Insol. | 164 |
| None | Oct. | Colorless | 1 93 | *Microlite* | Tant. | G.=5.5. Insol. | 164 |
| 100 | Cub. | Colorless | 1.93 | *Nantokite* | CuCl | G.=3.93. Sol. $H_2O$ | 30 |
| None | Oct. | Colorless | 1.95–1.99 | *Neotantalite* | Tant. | G.=5.2. Insol. | 164 |
| None | Oct. | Tinted± | 1.98± | *Hatchettolite* | Colum. | G.=4.8±. Insol. | 164 |
| | | | C. Yellow in thin section | | | | |
| 111 poor | Oct. | Yel., red, etc. | 1.74± | Spinel | Ox. | G.=3.6. Sol. $H_2SO_4$ | 62 |
| None | Dodec. | Yellow± | 1.74± | **Grossularite** | Sil. | G.=3.5±. Insol. | 180 |
| None | Rhom. | Yel., brown | 1.74± | *Caryocerite* | Sil. | G.=4.3. Dec. HCl | 420 |
| 100 | Cub. | Yel.-br. | 1.812 | *Beckelite* | Sil. | G =4.1. Sol. HCl | 420 |
| 111 | Oct. | Yellow | 1.82–7 | *Roméite* | Antim. | G.=5. Insol. | 159 |
| 111 | Oct. | Yel., br. | 1.96–2.02 | ***Pyrochlore*** | Tit. | G.=4.3. Dec. $H_2SO_4$ | 163 |
| None | Orth. | Br., yel. | 2.0± | *Wiikite* | Colum. | G.=3.8–4.8. Insol. | 167 |
| | | | D. Brown in thin section | | | | |
| 111 poor | Oct. | Br., red, etc. | 1.74± | Spinel | Ox. | G.=3.6. Sol. $H_2SO_4$ | 62 |
| None | Dodec. | Brown± | 1.74± | **Grossularite** | Sil. | G.=3.5±. Insol. | 180 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| None | Rhom. | Yel., br. | 1.74± | *Caryocerite* | Sil. | G.=4.3. Dec. HCl | 420 |
| None | ? | Brown | 1.77 | *Melanocerite* | Sil. | G.=4±. Sol. HCl | 420 |
| None | Dodec. | Br., red | 1.78–1.83 | **Almandite** | Sil. | G.=4.2±. Insol. | 178 |
| None | Prism. | Gr., br. | 1.78± | Gadolinite | Sil. | G.=4±. Gel. HCl | 424 |
| 111 fair | Oct. | Gr., bl., br. | 1.79–1.81 | *Gahnite* | Ox. | G.=4.5±. Sol. $H_2SO_4$ | 63 |
| None | Oct. | Brown | 1.8± | *Manganspinel* | Ox. | G.=4. Insol. | 62 |
| None | Tet. | Gr., br. | 1.82 | *Naegite* | Ox. | G.=4.1. Insol. | 65 |
| None | Mass. | Gr., br. | 1.86± | *Bindheimite* | Antim. | G.=4.6. Insol. | 160 |
| None | Dodec. | Br., red | 1.86–2.01 | Schorlomite | Sil. | G.=3.7–3.9. Insol. | 183 |
| 111 | Oct. | Yel., br. | 1.96–2.02 | ***Pyrochlore*** | Tit. | G.=4.3. Dec. $H_2SO_4$ | 159 |
| None | Orth. | Br., yel. | 2.0± | ***Wiikite*** | Colum. | G.=3.8–4.8. Insol. | 167 |

E. Red in thin section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 111 poor | Oct. | Red, br., etc. | 1.74± | Spinel | Ox. | G.=3.6. Sol. $H_2SO_4$ | 62 |
| None | Dodec. | Red | 1.76–1.82 | Rhodolite | Sil. | G.=3.8. Insol. | 178 |
| None | Dodec. | Red, br. | 1.77–1.81 | **Spessartite** | Sil. | G.=4±. Insol. | 178 |
| None | Dodec. | Red, br. | 1.78–1.83 | **Almandite** | Sil. | G.=4.2±. Insol. | 178 |
| None | Dodec. | Red, br. | 1.85–1.89 | **Andradite** | Sil. | G.=3.7–4.1. Insol. | 180 |
| None | Dodec. | Red, br. | 1.86–2.01 | Schorlomite | Sil. | G.=3.7–3.9. Insol. | 183 |

F. Green or blue in thin section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 111 poor | Oct. | Gr., red, etc. | 1.74± | Spinel | Ox. | G.=3.6. Sol. $H_2SO_4$ | 62 |
| None | Orth. | Green | 1.758 | *Yttrialite* | Sil. | G.=4.6. Sol. HCl | 414 |
| None | Isom. | Green | 1.77–1.80 | *Hercynite* | Ox. | G.=3.9. Insol. | 62 |
| None | Prism. | Gr., br. | 1.78± | Gadolinite | Sil. | G.=4±. Gel. HCl | 424 |
| 111 fair | Oct. | Gr., bl., br. | 1.79–1.81 | *Gahnite* | Ox. | G.=4.5±. Sol. $H_2SO_4$ | 63 |
| None | Tet. | Gr., br. | 1.82 | *Naegite* | Ox. | G.=4.1. Insol. | 65 |
| None | Mass. | Gr., br. | 1.86± | ***Bindehimite*** | Antim. | G.=4.6. Insol. | 160 |
| None | Dodec. | Green | 1.87± | ***Uvarovite*** | Sil. | G.=3.7. Insol. | 180 |

# TABLE II.—BIREFRINGENCE OF MINERALS

## O. Birefringence zero: $N_g - N_p = 0.000$

| Cleavage, Optic Orient. | Habit, etc. | Color | N | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 7.** Refringence positive and extreme: N>2.00 | | | |
| | | | | A. Uncolored in thin section | | | |
| 110 poor | Tet'h. | Colorless | 2.05 | *Eulytite* | Sil. | G.=6.1. Gel. HCl | 414 |
| None | Mass. | Gray, etc. | 2.06–2.25 | *Cerargyrite* | Hal. | G.=5.4–6. Sol. $NH_4OH$ | 30 |
| None | Oct. | Colorless | 2.065 | *Mosesite* | Hal. | Also biref. Soft | 34 |
| 111 poor | Oct. | Colorless | 2.087 | *Senarmontite* | $Sb_2O_3$ | G.=5.2. Sol. HCl | 43 |
| ? | Mass. | Colorless | 2.15–2.28 | *Bismutite* | Carb. | G.=7.0. Sol. $HNO_3$ | 86 |
| 111 dist. | Isom. | Colorless | 2.20 | *Lewisite* | Antim. | G.=4.95. Insol. | 162 |
| 111 perf. | Isom. | Tinted± | 2.42 | Diamond | C | G.=3.5. H.=10. Insol. | 13 |
| | | | | B. Yellow in thin section | | | |
| None | Mass. | Yellow | 2.0–2.1 | **Limonite** | Ox. | G.=3.8±. Sol. HCl | 47 |
| ? | Orth.? | Yel., br. | 2.0± | *Wiikite* | Colum. | G.=3.8.–4.8. Insol. | 167 |
| 111 dist. | Oct. | Yellow | 2.09 | *Schneebergite* | Antim. | G.=5.4. | 160 |
| ? | Orth. | Amber | 2.12–2.15 | *Yttrocrasite* | Tit. | G.=4.8. Sol. $H_2SO_4$ | 167 |
| 110 | Tet'h. | Yellow | 2.20 | *Miersite* | Hal. | G.=5.64. Sol. $NH_4OH$ | 30 |
| ? | Isom. | Yellow | 2.21 | *Weslienite* | Antim. | G.=4.97 | 160 |
| 100 | Cub. | Yel., br. | 2.33 | *Dysanalite* | Tit. | G.=4.1. Dec. HCl | 163 |
| 110 | Tet'h. | Yellow | 2.35 | *Marshite* | CuI | G.=5.59. Extr. disp. | 30 |
| 110 perf. | Tet'h. | Yel., br. | 2.37–2.47 | Sphalerite | ZnS | G.=4±. Sol. HCl | 19 |
| 111 perf. | Isom. | Tinted± | 2.42 | Diamond | C | G.=3.5. H.=10. Insol. | 13 |
| None | Dodec. | Yellow | 2.49 | *Eglestonite* | Hal. | G.=8.3. Dec. HCl | 37 |

C. Brown in thin section and not isometric

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ? | Orth.? | Br., yel. | 2.0± | *Wiikite* | Colum. | G.=3.8–4.8. Insol. | 167 |
| ? | Tet. | Red-br. | 2.05 | *Risoerite* | Tant. | G.=4.18. Sol. $H_2SO_4$ | 165 |
| None | Orth. | Red-br. | 2.06–2.26 | *Euxenite* | Tit. | G.=4.8. Insol. | 167 |
| 010 poor | Orth. | Brown | 2.10–2.25 | *Samarskite* | Colum. | G.=5.7±. Insol. | 166 |
| 111 poor | Tet. | Brown | 2.10–2.19 | *Fergusonite* | Colum. | G.=5.8. Dec. $H_2SO_4$ | 164 |
| None | Orth. | Br.-red | 2.13 | *Ampangabéite* | Colum. | G.=4.0–4.3. Sol. HCl | 166 |
| 010 poor | Orth. | Brown | 2.14 | *Blomstrandinite* | Tit. | G.=4.9±. Insol. | 167 |
| 010 poor | Orth. | Red-br. | 2.15 | *Yttrotantalite* | Tant. | G.=5.5–5.9. Insol. | 166 |
| ? | Orth. | Red-br. | 2.20–2.26 | *Eschynite* | Colum. | G.=4.9–5.1. Insol. | 167 |
| 100, 010 | Orth. | Red-br. | 2.215 | *Polymignite* | Tit. | G.=4.8. Insol. | 167 |
| ? | Tet. | Gr., br. | 2.30 | *Brannerite* | Ox. | G.=4.5–5.4. Sol. HCl | 69 |

D. Brown in thin section and isometric

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| None | Dodec. | Red, br. | 1.86–2.01 | Schorlomite | Sil. | G.=3.7–3.9. Insol. | 183 |
| 111 poor | Oct. | Brown | 2.05 | Picotite | Ox. | G.=4.1±. Sol. $H_2SO_4$ | 62 |
| None | Oct. | Br., red | 2.07–2.16 | **Chromite** | Ox. | G.=4.5. Insol. | 62 |
| None | Oct. | Red-br. | 2.19 | *Zirkelite* | Ox. | G.=4.72. Insol. | 164 |
| ? | Cub. | Red-br. | 2.20 | *Thorianite* | Ox. | G.=9.3. Sol. $HNO_3$ | 50 |
| 100 poor | Cub. | Brown | 2.30 | *Knopite* | Tit. | G.=4.1–4.3. Dec. $H_2SO_4$ | 163 |
| 100 | Cub. | Brown | 2.33 | *Dysanalite* | Tit. | G.=4.13. Dec. HCl | 163 |
| 110 perf. | Tet'h. | Brown | 2.37–2.47 | Sphalerite | ZnS | G.=4±. Sol. HCl | 19 |
| 100 poor | Cub. | Br., red | 2.38 | Perovskite | Tit. | G.=4. Dec. $H_2SO_4$ | 163 |

E. Red in thin section and not isometric

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ? | Tet. | Red-br. | 2.05 | *Risoerite* | Tant. | G.=4.18. Sol. $H_2SO_4$ | 165 |
| None | Orth. | Red-br. | 2.06–2.26 | *Euxenite* | Tit. | G.=4.8. Insol. | 167 |
| None | Orth. | Br.-red | 2.13 | *Ampangabéite* | Colum. | G.=4.0–4.3. Sol. HCl | 166 |

## TABLE II.—BIREFRINGENCE OF MINERALS

O. Birefringence zero: $N_g - N_p = 0.000$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | Color | N | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | E. Red in thin section and not isometric—*continued* | | | |
| 010 poor | Orth. | Red-br. | 2.15 | *Yttrotantalite* | Tant. | G.=5.5–5.9. Insol. | 166 |
| 100, 010 | Orth. | Red-br. | 2.20–2.26 | *Eschynite* | Colum. | G.=4.9–5.1. Insol. | 167 |
| None | Mass. | Red | 2.2–2.3 | **Limonite** | Ox. | G.=4±. Sol. HCl | 47 |
| | | | | F. Red in thin section and isometric | | | |
| None | Dodec. | Red, br. | 1.86–2.01 | Schorlomite | Sil. | G.=3.7–3.9. Insol. | 183 |
| None | Oct. | Br., red | 2.07–2.16 | **Chromite** | Ox. | G.=4.5. Insol. | 62 |
| ? | Dodec. | Red | 2.12–2.18 | *Koppite* | Tant. | G.=4.5. Dec. $H_2SO_4$ | 164 |
| ? | Oct. | Red | 2.16 | *Pyrrhite* | Tant. | G.=4.5. Dec. $H_2SO_4$ | 164 |
| None | Oct. | Red-br. | 2.19 | *Zirkelite* | Ox. | G.=4.72. Insol. | 164 |
| ? | Cub. | Red-br. | 2.20 | *Thorianite* | Ox. | G.=9.3. Sol. $HNO_3$ | 50 |
| 100 poor | Cub. | Br., red | 2 38 | Perovskite | Tit. | G.=4. Dec. $H_2SO_4$ | 163 |
| 111 perf. | Isom. | Tinted± | 2.42 | Diamond | C | G.=3.5. H.=10. Insol. | 13 |
| 100 poor | Oct. | Red | 2.69 | *Hauerite* | $MnS_2$ | G.=3.46. Sol. HCl | 24 |
| None | Tet'h. | Red | 2.72+ | Tetrahedrite | Cu, Sb, S | G.=4.4–5.1. Dec. $HNO_3$ | 26 |
| 111 poor | Oct. | Red | 2.85 | Cuprite | $Cu_2O$ | G.=6±. Sol. $H_2SO_4$ | 40 |
| | | | | G. Blue or green in thin section | | | |
| 100 | Cub. | Blue | 2.05 | *Percylite* | Hal. | G.=2.25. Sol. $HNO_3$ | 37 |
| 100 | Oct. | Green | 2.16 | *Manganosite* | MnO | G.=5.18. Sol. HCl | 41 |
| ? | Oct. | Green | 2.23 | *Bunsenite* | NiO | G.=6.4 Sol. HCl | 41 |
| ? | Tet. | Gr., br. | 2.30 | *Brannerite* | Ox. | G.=4.5–5.4. Sol. HCl | 69 |
| 111 perf. | Isom. | Tinted± | 2.42 | Diamond | C | G.=3.5. H.=10. Insol. | 13 |
| 100 perf. | Tet'h. | Green | 2.70 | *Alabandite* | MnS | G.=4.0. Sol. HCl | 20 |

I. Birefringence very weak: $N_g - N_p < 0.0035$

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 8.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically + or − | | | | | | | |
| 100 | ? | 0° | Tet. | *Villiaumite* | NaF | X = yellow; Z = red. Sign − | 30 |
| $10\bar{1}0$ dist. | Prism. | 0° | Hex. | *Yttrocalcite* | Hal. | G. = 3.2. Sol. HCl. Sign − | 36 |
| 111 dist. | Oct. | 0° | ? | *Faujasite* (−$H_2O$) | Sil. | Also isotropic. Sign + | 382 |
| X = *c* | Prism. | Sm. | Orth. | *Malladrite* | Hal. | G. = 2.75. Sign − | 37 |
| Y ⊥ 100 cl. | Prism. | 57° | Orth. | *Pilolite* | Sil. | X = *c*. G. = 2.1. Insol. HCl. Sign − | 389 |
| Z = *a* | Fib. | Lg. | Orth. | *Variscite* (−$H_2O$) | Phos. | *a* = lavender; *c* = violet | 140 |
| X = *c*. Y = *b* | 001 | Lg. | Orth. | *Avogadrite* | Hal. | G. = 2.6. Sign − | 34 |
| 001, 100 | Ps. Rh. | Sm. | Mon. | Gmelinite | Sil. | G. = 2.1. Dec. HCl. Sign ∓ | 385 |
| 001, 110 | Ps. Is. | 43° | Mon. | *Cryolite* | Hal. | X = *b*. $Z \wedge c = -44°$. Sign + | 34 |
| **Group 9a.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically + | | | | | | | |
| 111 dist. | Oct. | 0° | ? | *Faujasite* (−$H_2O$) | Sil. | Also isotropic | 382 |
| Z ⊥ 001 cl. | Prism. | 0° | Tet. | Apophyllite | Sil. | Abn. int. colors. G. = 2.35± | 262 |
| $10\bar{1}0$ perf. | Prism. | 0° | Hex. | ***Davyne*** | Sil. | K-cancrinite | 301 |
| 110 poor | Trap. | Sm. | ? | **Leucite** | Sil. | Also isotr. Alters easily | 291 |
| $10\bar{1}1$ dist. | Ps. Rh. | Sm. | Mon. | Chabazite | Sil. | G. = 2.1. Dec. HCl | 384 |
| 100, 010 | El. ∥ *c* | 70°± | Mon. | Phillipsite | Sil. | Ps. Tet. twin. G. = 2.2 | 393 |
| $Y \wedge c = 3°\pm$ | Fib. | 80° | Tr. | *Mesolite* | Sil. | Comp. twin. G. = 2.27 | 399 |
| $Z \wedge c = 20°$ | Fib. | Sm. | Tr. | *Pseudomesolite* | Sil. | Prism. cleav. | 399 |
| **Group 9b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically − | | | | | | | |
| X ⊥ 011 cl. | Prism. | 0° | Tet. | Apophyllite | Sil. | Abn. int. colors. G. = 2.35± | 262 |
| X = *c* | Pyr. | 0° | Tet. | *Cristobalite* | $SiO_2$ | G. = 2.27. Sol. HF | 53 |
| X = *c* | Prism. | 0° | Hex. | **NEPHELITE** | Sil. | G. = 2.6. Gel. HCl | 298 |
| $10\bar{1}0$ perf. | Prism. | 0° | Hex. | ***Davyne*** | Sil. | K-cancrinite | 301 |

## TABLE II.—BIREFRINGENCE OF MINERALS

I. Birefringence very weak: $N_g - N_p < 0.0035$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 9b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically—, *continued* | | | | | | | |
| $X = c$ | Prism. | 0°± | Hex. | *Milarite* | Sil. | G. = 2.57. Insol. | **429** |
| 001 diff. | Ps. Is. | Sm. | ? | **Analcite** | Sil. | Comp. twin. Isotr. at 130° C. | 293 |
| 100 | Ps. Is. | Sm. | ? | *Chlorocalcite* | Hal. | Comp. twin. Hygrosc. | 33 |
| Z⊥010 cl. | Prism. | 60°± | Orth. | **Cordierite** | Sil. | Ps. Hex. twin. $X = c$. Colorless or X = yel., **Y = blue, Z = blue** | 307 |
| $10\bar{1}1$ dist. | Ps. Rh. | Sm. | Mon. | Chabazite | Sil. | G. = 2.1. Dec. HCl | 384 |
| $X \wedge c = 43°$ | Var. | 71° | Mon. | *Bloedite* | Sul. | G. = 2.23. Sol. $H_2O$ | 112 |
| **Group 10a.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically + | | | | | | | |
| Z⊥001 cl. | Prism. | 0° | Tet. | Apophyllite | Sil. | Abn. int. colors. G. = 2.35± | 262 |
| $10\bar{1}0$ dist. | Rhom. | 0° | Rhom. | *Rinneite* | Hal. | Abn. int. colors. G. = 2.35 | 33 |
| $Z = c$ | ? | 0° | Rhom. | *Chlormankalite* | Hal. | Yellow. Deliques. | 33 |
| Z⊥001 cl. | 001 | Sm. | Mon. | **Penninite** | Sil. | Green. Ultra blue int. colors | 281 |
| **Group 10b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically − | | | | | | | |
| X⊥001 cl. | Prism. | 0° | Tet. | Apophyllite | Sil. | Abn. int. colors. G. = 2.35± | 262 |
| $X = c$ | Prism. | 0° | Hex. | **NEPHELITE** | Sil. | G. = 2.6. Gel. HCl | 298 |
| $X = c$ | Prism. | 0°± | Hex. | *Milarite* | Sil. | G. = 2.57. Insol. | 429 |
| Z⊥010 cl. | Prism. | 60°± | Orth. | **Cordierite** | Sil. | Ps. Hex. twin. $X = c$. Colorless or X = yel., **Y = blue, Z = blue** | 307 |
| X⊥001 cl. | 001 | Sm. | Mon. | **Penninite** | Sil. | Green. Ultra blue int. colors | 281 |
| X⊥001 cl. | 001 | Sm. | Mon. | Delessite | Sil. | Green or pink. Str. disp. | 282 |
| X⊥001 cl. | 001 | Sm. | Mon. | *Kaemmererite* | Sil. | Purple: $X < Y = Z$. G. = 2.8± | 286 |
| **Group 11a.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically + | | | | | | | |
| Z⊥001 cl. | 001 | 0°± | Tet. | *Metatorbernite* | Phos. | Abn. int. colors | **145** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z=*c* | ? | 0° | Rhom. | *Chlormankalite* | Hal. | Yellow. Deliques. G.=2.3 | 33 |
| Z⊥0001 cl. | Var. | 0° | Rhom. | Eudialite | Sil. | Colorless or X=yel., Z=red | 417 |
| Z⊥001 cl. | 001 | Sm. | Mon. | Ripidolite | Sil. | Green. Abn. int. colors | 284 |
| **Group 11b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically − | | | | | | | |
| X=*c* | Prism. | 0° | Hex. | **Apatite** | Phos. | Colorless or tinted | 129 |
| 10$\bar{1}$0 dist. | ? | 0° | Hex. | *Merrillite* | Phos. | Also biax.? Sol. $HNO_3$ | 149 |
| X⊥0001 cl. | ? | 0° | Hex. | *Gillespite* | Sil. | G.=3.33. Sol. HCl | 401 |
| X⊥0001 cl. | Var. | 0° | Rhom. | *Eucolite* | Sil. | Colorless or X=red, Z=yel. | 417 |
| X⊥001 cl. | 001 | Sm. | Mon. | Diabantite | Sil. | Green. Abn. int. colors | 283 |
| X⊥001 cl. | 001 | Sm. | Mon. | Aphrosiderite | Sil. | Green. Abn. int. colors | 284 |
| X⊥001 cl. | 001 | Sm. | Mon. | Daphnite | Sil. | Green. Abn. int. colors | 285 |
| X⊥001 cl. | 001 | Sm. | Mon. | *Kaemmererite* | Sil. | Purple: X<Y=Z. G.=2.8± | 286 |
| **Group 12.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically + or − | | | | | | | |
| Z=*c* | Prism. | 0° | Tet. | *Viluite* | Sil. | Tinted ±. Sign + | 207 |
| X=*c* | Prism. | 0° | Tet. | Vesuvianite | Sil. | Tinted ±. Sign − | 207 |
| X=*c* | Prism. | 0° | Hex. | **Chlorapatite** | Phos. | G.=3.2. Sign − | 129 |
| Z∧*c*=10°± | 010 | 69° | Mon. | ***Sapphirine*** | Sil. | Blue; pleo. Sign − | 427 |
| 001, 010? | Fib. | ? | Mon. | *Sarcopsite* | Phos. | Yellow. G.=3.64. Sign? | 134 |
| **Group 13.** Refringence positive and high: $N_o$ or $N_m > 1.74 < 2.00$. Optically + or − | | | | | | | |
| X⊥0001 cl. | Prism. | 0° | Hex. | *Swedenborgite* | Antim. | G.=4.3. Insol. Sign− | 149 |
| No cleav. | Prism. | 25° | Orth. | *Cerite* | Sil. | Colorless or Z=red. Sign + | 422 |
| Two at 90° | ? | Sm. | Orth. | *Hyalotekite* | Sil. | G.=3.8. Sol. HF. Sign + | 422 |
| ? | Fib. | Lg. | Mon. | *Agricolite* | Sil. | G.=6. Gel. HCl. Sign +? | 414 |
| **Group 14.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically + or − | | | | | | | |
| 110 poor | Ps. Is. | 0° | ? | *Eulytite* | Sil. | G.=6.1. Gel. HCl. Sign − | 414 |
| X=*c*. Y=*b* | Ps. Is. | 90°± | Orth. | Perovskite | Tit. | Gray or brown. Sign + | 163 |
| ? | Fib. | Lg. | Mon. | *Agricolite* | Sil. | G.=6. Gel. HCl. Sign +? | 414 |

# TABLE II. BIREFRINGENCE OF MINERALS

*

## II. Birefringence weak: $N_g - N_p > 0.0035 < 0.0095$

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 15a.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically + | | | | | | | |
| A. No visible cleavage | | | | | | | |
| Z⊥0001 pt. | 0001 | 0° | Hex. | **Ice** | $H_2O$ | Skel. cryst. are "snow" | 40 |
| Z⊥001 pt. | 001 | 35° | Orth. | Tridymite | $SiO_2$ | Ps. Hex. twin. G.=2.27 | 58 |
| X=*c*=elong. | Fib. | Sm. | Orth. | *Paraluminite* | Sul. | G.=1.66. Sol. HCl | 109 |
| Z∧*c*=28°± | Fib. | Mod. | Mon. | *Pickeringite* | Sul. | Y=*b*. G=1.85. Sol. $H_2O$ | 116 |
| 10$\bar{1}$0 dist. | Ps. Rh. | Sm. | Mon. | Gmelinite | Sil. | Comp. twin. G.=2.75 | 385 |
| Z∧001 cl.=22° | Prism. | 76° | Mon. | *Pachnolite* | Hal. | 100 twin. G.=3.0 | 36 |
| B. One or more visible cleavages | | | | | | | |
| X⊥100 cl. | El. ‖ *c* | 50° | Orth. | *Ferrierite* | Sil. | Z=*c*. G.=2.15 | 389 |
| X⊥010 cl. | *c* or 010 | Lg. | Mon. | *Mordenite* | Sil. | Z∧*c*=−73°. G.=2.1 | 398 |
| X∧$\bar{2}$01 cl.=37° | Prism. | 50° | Mon. | *Boussingaultite* | Sul. | Y=*b*. G.=1.72 | 113 |
| X⊥010 cl. | *c* or 010 | 69° | Mon. | ***Alunogen*** | Sul. | Z∧*c*=42°. G.=1.65 | 109 |
| **Group 15b.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically − | | | | | | | |
| X⊥001 cl. | Pyr. | 0° | Tet. | *Chiolite* | Hal. | G.=3. Very rare | 34 |
| 10$\bar{1}$0 perf. | Acic. | 0° | Hex. | *Ettringite* | Sul. | G.=1.8. Sol. HCl | 115 |
| 10$\bar{1}$0 dist. | Ps. Rh. | Sm. | Mon. | Gmelinite | Sil. | Comp. twin. G.=2.75 | 385 |
| X∧001 cl.=41° | Ps. Is. | 50° | Mon. | *Thomsenolite* | Hal. | Z=*b*. G.=3.0 | 36 |
| Y∧*c*=Lg. | Acic. | Mod. | Mon. | *Gearksutite* | Hal. | Chalky. G.=2.75 | 35 |
| Z∧100 cl.=29° | Prism. | 76° | Mon. | Mirabilite | Sul. | Y=*b*. G.=1.46. Sol. $H_2O$ | 97 |

**Group 16a.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically +

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $10\bar{1}0$ dist. | Acic. | 0° | Hex. | *Leifite* | Sil. | G. = 2.27. Sol. HCl | 429 |
| $10\bar{1}0$ dist. | 0001 | 0° | Rhom. | *Aphthitalite* | Sul. | G. = 2.7. Sol. $H_2O$ | 96 |
| $10\bar{1}1$ dist. | Ps. Rh. | Sm. | Mon. | Chabazite | Sil. | 0001 twin. G. = 2.1 | 384 |
| $X \wedge c = 4°$ | 010 | 39° | Mon. | *Wellsite* | Sil. | $Y = b$. G. = 2.3 | 395 |
| $Y \perp 010$ cl. | El. $\parallel c$ | 43° | Mon. | ***Harmotome*** | Sil. | $X \wedge c = 62°$. G. = 2.5 | 395 |
| $Z \wedge c = 20°$ | El. $\parallel c$ | 70° | Mon. | Phillipsite | Sil. | $Y = b$. G. = 2.0 | 393 |
| $Z \wedge c = 50°$ | 010 | 63° | Mon. | *Prosopite* | Hal. | $Y = b$. G. = 2.9 | 34 |
| $Y \wedge$ fib. = Lg. | Fib. | Lg. | Mon. | *Zn-Cu-Melanterite* | Sul. | $Z = b$. G. = 2 | 106 |

B. One or more visible cleavages

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $10\bar{1}0$ perf. | Prism. | 0° | Hex. | *Microsommite* | Sil. | G. = 2.45. Gel. HCl | 301 |
| $X \perp 001$ cl. | Prism. | 37° | Orth. | *Struvite* | Phos. | $Z \perp 010$ cl. 001 twin. | 151 |
| $Z \perp 010$ cl. | Prism. | 54° ± | Orth. | Thomsonite | Sil. | $Y = c$. G. = 2.3 | 387 |
| $X \perp$ cleav. | Fib. | 52° | Orth. | *Gonnardite* | Sil. | $Z = c$. G. = 2.25 | 387 |
| $Z \perp 010$ cl. | 010 | 34° ± | Mon. | Heulandite | Sil. | $Y \wedge c = 6°$. G. = 2.2 | 397 |
| $Y \perp 010$ cl. | $c$ or 010 | 58° | Mon. | Gypsum | Sul. | $Z \wedge c = 52°$. G. = 2.94 | 104 |
| $Z \parallel$ elong. | Lath. | Lg. | Tr.? | *Chalcoalumite* | Sul. | Bl.-green. Abn. int. colors | 117 |
| 001, 010 | $a$ or 010 | Lg. | Tr. | **PLAGIOCLASE** | Sil. | Lam. twin. G. = 2.6 ± | 368 |

**Group 16b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically −

A. No visible cleavage and no marked elongation

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X = c$ | Prism. | 0° | Hex. | *β-Kaliophilite* | Sil. | G. = 2.56. Gel. HCl | 300 |
| $X = c$ | Prism. | 0° | Hex. | **NEPHELITE** | Sil. | G. = 2.6. Gel. HCl | 298 |
| $X = c$ | Rhom. | 0° | Rhom. | *Levynite* | Sil. | G. = 2.1. Gel. HCl | 386 |
| $10\bar{1}1$ dist. | ? | 0° | Rhom. | *Tachyhydrite* | Hal. | Deliques. | 32 |
| $X = c$ | ? | 39° | Orth. | *α-Kaliophilite* | Sil. | G. = 2.6. Gel. HCl | 300 |
| $Z \perp 010$ cl. | Prism. | 60° ± | Orth. | Cordierite | Sil. | Ps. Hex. twin. $X = c$. Colorless or X = yel., Y = blue, Z = blue | 307 |

# TABLE II.—BIREFRINGENCE OF MINERALS

## II. BIREFRINGENCE WEAK: $N_g - N_p > 0.0035 < 0.0095$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 16b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically −, *continued* | | | |
| | | | | A. No visible cleavage and no marked elongation—*continued* | | | |
| $10\bar{1}1$ dist. | Ps. Rh. | Sm. | Mon. | Chabazite | Sil. | 0001 twin. G. = 2.1 | 384 |
| $X=b$. $Z=a\pm$ | Ps. Tet. | 83° | Mon. | *Gismondite* | Sil. | G. = 2.27. Gel. HCl | 373 |
| $Z \wedge c$ = Sm. | Tab. | 86° | Mon. | *Leonite* | Sul. | $Y=b$. G. = 2.25. Sol. **$H_2O$** | 112 |
| No cleav. | ? | 84° | Mon. | *Vanthoffite* | Sul. | G. = 2.7. Sol. $H_2O$ | 111 |
| ? | Prism. | 13°± | Tr. | *Carnegieite* | Sil. | G. = 2.5. Gel. HCl | 299 |
| | | | | B. No visible cleavage and marked elongation | | | |
| 100 dist. | El. ‖ $c$ | 0° | Tet. | Marialite | Sil. | G. = 2.57. Also +? | 296 |
| $X=c$? | Fib. | 0°? | Hex.? | Chalcedonite | $SiO_2$ | G. = 2.6. Sol. HF | 57 |
| $Z=c$ | Fib. | 25°± | Orth. | Sepiolite | Sil. | G. = 2.0 | 410 |
| $Z \wedge c = 37°$ | Fib. | Mod. | Mon. | *Pickeringite* | Sul. | $Y=b$. G. = 1.85 | 116 |
| $Z \wedge c = 29°$ | Fib. | Sm. | Mon. | *Apjohnite* | Sul. | $Y=b$. G. = 1.8 | 117 |
| $X \wedge c = 43°$ | Prism. | 71° | Mon. | *Bloedite* | Sul. | Also 001 tab. G. = 2.2 | 112 |
| $Z \wedge c = 30°$ | Fib. | ? | Mon. | *Halotrichite* | Sul. | G. = 1.9. Sol. $H_2O$ | 116 |
| | | | | C. One or more visible cleavages | | | |
| **$10\bar{1}0$ perf.** | Prism. | 0° | Hex. | Cancrinite | Sil. | G. = 2.45. Gel. HCl | 301 |
| **$10\bar{1}0$ perf.** | Prism. | 0° | Hex. | ***Natrodavyne*** | Sil. | G. = 2.45. Gel. HCl | 301 |
| **$Y \perp 010$ cl.** | 010 | 33° | Mon. | Stilbite | Sil. | $X \wedge c = 5°$. G. = 2.15 | 395 |
| **110 perf.** | Prism. | 36° | Mon. | Scolecite | Sil. | $X \wedge c = 16°$. $Z=b$. G. = 2.3 | 390 |
| **100 perf.** | ? | Lg. | Mon. | *Searlesite* | Sil. | $Z=b$. $X \wedge c = 30°$ | 423 |
| **001, 010** | Prism. | 70° | Mon. | **ADULARIA** | Sil. | $X \wedge a = 6°$. $Z=b$. G. = 2.56 | 361 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 001, 010 | 010 | Sm. | Mon. | **SANIDINE** | Sil. | X∧*a*=6°. Y=*b*. G.=2.57 | 361 |
| 001, 010 | Prism. | 76°± | Mon. | **Hyalophane** | Sil. | X∧*a*=0°–20°. Z=*b* | 360 |
| 001, 010 | Prism. | 83°± | Tr. | **MICROCLINE** | Sil. | Two sets lam. twin. | 364 |
| 001, 010 | Prism. | 45°± | Tr. | **ANORTHOCLASE** | Sil. | Lam. twin. Also 010 tab. | 366 |
| 001, 010 | *a* or 010 | 85°± | Tr. | **OLIGOCLASE** | Sil. | Lam. twin. Also prism. | 371 |

**Group 17a.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically +

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z=*c* | Prism. | 0° | Hex. | **QUARTZ** | $SiO_2$ | G.=2.65. Sol. HF | 54 |
| 10$\bar{1}$0 poor | Prism. | 0° | Rhom. | *Coquimbite* | Sul. | Abn. int. colors. G.=2.1 | 107 |
| Z ‖ fib. | Fib. | 0° | ? | *Ceruleolactite* | Phos. | Colorless or blue | 143 |
| Z ‖ fib. | Fib. | Sm. | Orth. | *Nouméite* | Sil. | Green. Dec. HCl | 261 |
| Z∧fib.=31° | Fib. | ? | Mon. | *Jurupaite* | Sil. | G.=2.75. Sol. HCl | 412 |
| Z⊥010 cl. | El. ‖ *c* | 47° | Mon. | *Bazzite* | Sil. | X∧*a*=2°. 100 twin. | 438 |

B. One or more visible cleavages

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z⊥010 cl. | Prism. | 54°± | Or. | Thomsonite | Sil. | Y ‖ elong. G.=2.3 | 387 |
| Z⊥001 cl. | 001 | Sm. | Mon. | **Clinochlore** | Sil. | Green; weak pleo. G.=2.7± | 283 |
| Z⊥001 cl. | 001 | Sm. | Mon. | Prochlorite | Sil. | Green; weak pleo. G.=2.8+ | 284 |
| Z∧001 cl.=28° | 001 | 30° | Mon. | *Eudidymite* | Sil. | 001 twin. G.=2.55 | 418 |
| 001, 010 | *a* or 010 | 82°± | Tr. | **ANDESINE** | Sil. | Lam. twin. | 372 |
| 001, 010 | *a* or 010 | 82°± | Tr. | **LABRADORITE** | Sil. | Lam. twin | 374 |

**Group 17b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically −

B. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 dist. | El. ‖ *c* | 0° | Tet. | Marialite | Sil. | G.=2.57. Also+? | 296 |
| 0001 dist. | Prism. | 0° | Hex. | *Eucryptite* | Sil. | G.=2.67. Gel. HCl | 300 |
| X=*c*? | Fib. | 0° | Hex.? | Chalcedonite | $SiO_2$ | G.=2.6. Sol. HF | 57 |
| X=*c* | Prism. | 0° | Hex. | *β-Kaliophilite* | Sil. | G.=2.55. Gel. HCl | 300 |
| X=*c* | Prism. | 0° | Hex. | **NEPHELITE** | Sil. | G.=2.6. Gel. HCl | 298 |

## TABLE II.—BIREFRINGENCE OF MINERALS

II. BIREFRINGENCE WEAK: $N_g - N_p > 0.0035 < 0.0095$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 17b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically −, *continued* | | | |
| | | | | B. No visible cleavage—*continued* | | | |
| X=*c* | Prism. | 0° | Hex. | Beryl | Sil. | Colorless; blue, green; pleo. | 212 |
| ? | ? | 39° | Orth. | *α-Kaliophilite* | Sil. | Ps. Hex. twin. G.=2.5± | 300 |
| Z⊥010 cl. | Prism. | 60°± | Orth. | **Cordierite** | Sil. | Ps. Hex. twin. X=*c*. Colorless or X=yel., Y=blue, Z=blue | 307 |
| X=*b*. Z=*a*± | Ps. Tet. | 83° | Mon. | *Gismondite* | Sil. | G.=2.27. Gel. HCl | 373 |
| Z∧*c*=12° | Fib. | Lg. | Mon. | ***Crestmorite*** | Sil. | G.=2.2. Dec. HCl | 409 |
| | | | | B. One visible cleavage (lamellar) | | | |
| 001 perf. | 001 | 0° | Tet. | *Metazeunerite* | Arsen. | Green: X<Z. G.=3. Sol. $HNO_3$ | 146 |
| 0001 perf. | 0001 | 0° | Rhom. | *Reyerite* | Sil. | G.=2.52. Sol. HCl | 408 |
| X⊥0001 cl. | 0001 | 0°± | Rhom. | *Zeophyllite* | Sil. | G.=2.76. Also biax. | 408 |
| X⊥001 cl. | Ps. Hex. | 0°± | Mon.? | *Calcioferrite* | Phos. | G.=2.53. Dec. HCl | 156 |
| 001 perf. | 001 | 60° | Mon. | **Kaolinite** | Sil. | Y∧*a*=11°. Z=*b*. G.=2.6 | 264 |
| X⊥001 cl.± | 001 | ? | Mon. | *Faratsihite* | Sil. | Sol. HCl | 416 |
| X⊥001 cl.± | 001 | 90°± | Mon. | *Miloschite* | Sil. | Bl.-green. G.=2.1 | 416 |
| X⊥001 cl.± | 001 | 40°± | Mon. | **Antigorite** | Sil. | Green; weak pleo. G.=2.57 | 280 |
| X⊥001 cl.± | 001 | Sm. | Mon. | *Jenkinsite* | Sil. | Green; weak pleo. Sol. HCl | 281 |
| | | | | C. Two visible cleavages | | | |
| 100, 010 | Prism. | 0°± | Orth. | *β-Hopeite* | Phos. | X=*b*. G.=3.0 | 124 |
| 001, 010 | 001 | 23° | Orth. | *Epididymite* | Sil. | X=*b*. Y=*c*. G.=3.55 | 418 |
| 001, 010 | Prism. | 75°± | Mon. | **Hyalophane** | Sil. | X∧*a*=0°–25°. Z=*b*. | 360 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 001, 010 | *a* or 010 | 85°± | Tr. | **OLIGOCLASE** | Sil. | Lam. twin. | 371 |
| 001, 010 | *a* or 010 | 82°± | Tr. | **ANDESINE** | Sil. | Lam. twin. | 372 |
| 001, 010 | *a* or 010 | 85°± | Tr. | **BYTOWNITE** | Sil. | Lam. twin. | 376 |

**Group 18a.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically +

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 001, 110 | 001 | 0° | Tet. | **Akermanite** | Sil. | G. = 3.18. Gel. HCl | 209 |
| $Z = c$ | ? | 0° | Rhom. | *Gorceixite* | Phos. | G. = 3.1 | 153 |
| 0001 dist. | Var. | 0° | Rhom. | *Eudialite* | Sil. | Colorless or yel. to red | 417 |
| Z ‖ fib. | Fib. | Sm. | Orth. | *Nouméite* | Sil. | Gr.; weak pleo. G. = 2.5± | 261 |
| Z ‖ fib. | Fib. | Sm. | Orth. | *Foshagite* | Sil. | G. = 2.36. Gel. HCl | 408 |
| $Z = c$ | Ps. Tet. | 0°± | Orth. | *Uranochalcite* | Sul. | X, Y = green, Z = gr.-yellow | 117 |

B. One or more visible cleavages

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0001 perf. | 0001 | 0° | Rhom. | *Goyazite* | Phos. | Colorless or yellow | 153 |
| Z⊥001 cl. | Prism. | 60°+ | Orth. | Topaz | Sil. | $Y = b$. G. = 3.55± | 198 |
| 001, 110 | 001 | 51° | Orth. | Celestite | Sul. | $Y = b$. $Z = a$. G. = 4.0 | 99 |
| 110 at 88° | Prism. | 70°± | Orth. | **ENSTATITE** | Sil. | $Y = b$. $Z = c$. G. = 3.2 | 217 |
| 110 at 88° | Prism. | 53° | Mon. | **CLINOENSTATITE** | Sil. | $Y = b$. $Z \wedge c = +22°$ | 220 |
| Z⊥001 cl.± | 001 | Sm. | Mon. | Prochlorite | Sil. | $Y = b$. Green; weak pleo. | 284 |
| 010, 100 | El. ‖ *c* | 40° | Mon. | *Picropharmacolite* | Arsen. | $X \wedge c = 37°$. $Y = b$ | 125 |

**Group 18b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically −

A. No visible cleavage and no marked elongation

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X = c$ | Prism. | 0° | Hex. | **Apatite** | Phos. | Colorless or tinted | 129 |
| $X = c$ | Prism. | 0° | Hex. | *Wilkeite* | Phos. | G. = 3.2. Sol. HCl | 440 |
| 0001 poor | Prism. | 0° | Hex. | Beryl | Sil. | G. = 2.6–2.9. Sol. HF | 212 |
| 0001 dist. | Var. | 0° | Rhom. | *Eucolite* | Sil. | Colorless or yel. to red | 417 |
| X ‖ 110 cl. | Prism. | 84° | Orth. | **Andalusite** | Sil. | $Y = b$. Colorless or yel. to red | 201 |

# TABLE II.—BIREFRINGENCE OF MINERALS

## II. Birefringence weak: $N_g - N_p > 0.0035 < 0.0095$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 18b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically −, *continued* | | | | | | | |
| A. No visible cleavage and no marked elongation—*continued* | | | | | | | |
| X=*b*. Y=*c* | Prism. | 89° | Orth. | Danburite | Sil. | G.=3.0. Sol. HF | 210 |
| X∧*c*=35°± | El. ‖ *b* | Lg. | Mon. | **Allanite** | Sil. | Y.=*b*. X=yellow, Z=brown | 316 |
| ? | ? | Lg. | Mon. | *Palaite* | Phos. | G.=3.2. Sol. HCl | 124 |
| B. No visible cleavage and marked elongation | | | | | | | |
| X=*c* | c or 0001 | 0° | Hex. | *Francolite* | Phos. | G.=3.1. Sol. HCl | 161 |
| Z ‖ fib. | Fib. | 0° | Hex. | *Dahllite* | Phos. | Also biax. G.=3. | 161 |
| Z ‖ 110 cl. | Prism. | 70°? | Orth. | *Hillebrandite* | Sil. | Y=*b*. G.=2.7. Sol. HCl | 408 |
| Z∧100 cl.=12° | El. ‖ *c* | Lg. | Mon. | *Crestmorite* | Sil. | G.=2.22. Dec. HCl | 409 |
| C. One or more visible cleavages | | | | | | | |
| 0001 perf. | Var. | 0° | Hex. | *Fluocerite* | Hal. | G.=5.7–6.1. Sol. $H_2SO_4$ | 33 |
| 110 at 56° | Prism. | Sm. | Mon. | *Crossite* | Sil. | X∧*c*=70°±. Z=*b*. X=yellow, Z=violet | 259 |
| X⊥001 cl. | 001 | Sm. | Mon. | Thuringite | Sil. | X=colorless; Y, Z=green | 285 |
| X⊥001 cl. | 001 | Sm. | Mon. | *Jenkinsite* | Sil. | Olive green | 281 |
| **Group 19a.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically + | | | | | | | |
| A. No visible cleavage | | | | | | | |
| 0001 dist. | Rhom. | 0° | Rhom. | *Florencite* | Phos. | G.=3.6. Brownish in mass | 142 |
| X=*c*. Y=*b* | Prism. | 52° | Orth. | *Harstigite* | Sil. | G.=3 | 432 |
| X⊥100 cl. | 100 | Lg. | Orth. | *Dewindtite* | Phos. | Y=*c*. Yellow. G.=4 | 148 |
| 001 dist. | Ps. Rh. | Sm. | Mon. | *Fillowite* | Phos. | Yellow. G.=3.4 | 123 |
| No cleav. | ? | 90°± | Tr.? | *Serendibite* | Sil. | Lam. twin. Blue; pleo. | 425 |

B. One or more visible cleavages

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 010 perf. | Prism. | 30°± | Orth. | **Zoisite** | Sil. | Y=*b* (or *c*). Z=*a*. G.=3.3 | 311 |
| Z ∥ 110 cl. | Prism. | 70°± | Orth. | **ENSTATITE** | Sil. | Y=*b*. G.=3.2 | 217 |
| 001, 010 | Prism. | Var. | Orth. | *Triphylite* | Phos. | X=*c*. Y=*a*. G.=3.5 | 149 |
| Z∧001 cl.=20° | El. ∥ *b* | 85°± | Mon. | **Clinozoisite** | Sil. | Y=*b*. G.=3.36 | 312 |
| 110 at 88° | Prism. | 53° | Mon. | **Clinoenstatite** | Sil. | Z∧*c*=+22°. Y=*b* | 220 |
| Z∧100 cl.=4° | Prism. | Mod. | Mon. | *Triploidite* | Phos. | X=*b*. G.=3.7. Sol. HCl | 134 |
| Z⊥001 cl.± | 001 | 50°± | Tr. | Chloritoid | Sil. | X=green, Y=blue, Z=yellow | 438 |

**Group 19b.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X=*c* | Prism. | 0° | Tet. | Vesuvianite | Sil. | Colorless or tinted. G.=3.4 | 207 |
| X=*c* | Prism. | 0° | Tet. | **Gehlenite** | Sil. | G.=3.0. Gel. HCl | 209 |
| 0001 poor | Prism. | 0° | Hex. | *Svabite* | Arsen. | G.=3.5. Sol. HCl | 129 |
| Y=*b* | Ps. Is. | Sm. | Mon. | *Pharmacosiderite* | Phos. | G.=3.0. Sol. HCl | 143 |
| Z∧*c*=10° | 010 | 69° | Mon. | ***Sapphirine*** | Sil. | Y=*b*. X=yellow; Y, Z=blue | 427 |
| X∧*c*=35°± | El. ∥ *b* | Lg. | Mon. | **Allanite** | Sil. | Y=*b*. X=yellow; Z=brown | 316 |

B. One or more visible cleavages

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 at 56° | Prism. | Lg. | Mon. | **Riebeckite** | Sil. | X∧*c*=Sm. Z=*b*. X, Y=blue; Z=green | 257 |
| 110 at 56° | Prism. | Lg. | Mon. | Arfvedsonite | Sil. | Z=*b*. X=blue, Y=violet, Z=yellow | 257 |
| 110 at 56° | Prism. | Sm. | Mon. | *Crossite* | Sil. | Z=*b*. X=yellow, Y=blue, Z=violet | 259 |

**Group 20a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10$\bar{1}$1 | Rhom. | 0° | Rhom. | *Arsenioplcite* | Arsen. | Blood red. Sol. HCl | 153 |
| No cleav. | Prism. | 25° | Orth. | *Cerite* | Sil. | Colorless or red: X<Z | 422 |
| X⊥100 cl. | 100 | Lg. | Orth. | *Dewindtite* | Phos. | Yellow. G.=4.1 | 148 |
| Z∧*c*=+8° | Prism. | 85° | Mon. | *Gadolinite* | Sil. | Y=*b*. G.=4.3±. Gel. HCl | 424 |
| 110 at 66° | Prism. | 32° | Tr. | Enigmatite | Sil. | Y=*b*. Z∧*c*=45°±. Brown; pleo. | 428 |
| Z⊥001 cl.± | 001 | 50°± | Tr. | Chloritoid | Sil. | X=green, Y=blue, Z=yellow | 438 |

# TABLE II.—BIREFRINGENCE OF MINERALS

## II. BIREFRINGENCE WEAK: $N_g - N_p > 0.0035 < 0.0095$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 20b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically − | | | | | | | |
| 0001 part. | Var. | 0° | Hex. | Corundum | $Al_2O_3$ | Colorless or blue, red, etc. | 43 |
| 0001 dist. | Rhom. | 0° | Rhom. | *Beudantite* | Sul. | Also biax. G.=4.1 | 119 |
| 0001 dist. | Rhom. | 0° | Rhom. | *Corkite* | Sul. | Also biax. G.=4.2 | 119 |
| **Group 21.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically + or − | | | | | | | |
| X ‖ fib. | Fib. | 0° | Tet. | *Minium* | $Pb_3O_4$ | X=red−br., Z=colorless. Sign ? | 65 |
| 111 poor | Ps. Is. | Lg. | Orth. | *Senarmontite* | $Sb_2O_3$ | Octahedral. Sign + | 43 |
| X=*a*. Z=*b* | Ps. Is. | 90°± | Orth. | *Dysanalite* | Tit. | X=gray. Z=green. Sign + | 163 |
| ? | Acic. | ? | Orth. | *Cervantite* | Ox. | G.=4. Sol. HCl | 67 |
| III. BIREFRINGENCE MODERATE: $N_g - N_p > 0.0095 < 0.0185$ | | | | | | | |
| **Group 22a.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically + | | | | | | | |
| A. No visible cleavage | | | | | | | |
| Z ‖ elong. | Fib. | 0°? | ? | Chrysocolla | Sil. | Opt. data discordant | 411 |
| ? | Conch. | 36° | Orth. | *Taylorite* | Sul. | G.=2.5? Sol. $H_2O$ | 96 |
| X ‖ fib. | Fib. | Lg. | Orth. | *Aluminite* | Sul. | G.=1.66. Sol. HCl | 109 |
| Z ‖ fib. | El. ‖ *c* | 65°? | Orth. | *Erionite* | Sil. | G.=2.0. Sol. HCl | 389 |
| Y⊥001 cl. | Var. | 83° | Orth. | *Thenardite* | Sul. | G.=2.68. Sol. $H_2O$ | 96 |
| Z ‖ 110 cl. | Fib. | 0°± | Mon. | *Laubanite* | Sil. | G.=2.2. Gel. HCl | 438 |
| B. One or more visible cleavages | | | | | | | |
| 100, 110 | Prism. | 0° | Tet. | *Sellaite* | $MgF_2$ | G.=3.17. Sol. $H_2SO_4$ | 32 |
| X ‖ 110 cl. | Prism. | 62°± | Orth. | Natrolite | Sil. | Y=*b*. Ps. Tet. G.=2.55 | 390 |
| 20$\bar{1}$ perf. | Prism. | 48° | Mon. | *Picromerite* | Sul. | $X \wedge c = 14°$. Y=*b*. G.=2.1 | 112 |
| X⊥010 cl. | Fib. | 69° | Mon. | *Alunogen* | Sul. | $Z \wedge c = 42°$. G.=1.65. Sol. $H_2O$ | 109 |
| 001, 110 | Fib. | 86° | Mon. | *Melanterite* | Sul. | Y=*b*; $Z \wedge c = -62°$. G.=1.9 | 106 |

**Group 22b.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Y ‖ 110 cl. | Prism. | 40° | Orth. | *Lecontite* | Sul. | X = *a*. Sol. $H_2O$ | 97 |

**Group 23a.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically +

A. Extinction parallel with elongation or cleavage in chief zones

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z = *c* | ? | 0° | ? | *Douglasite* | Hal. | Sol. $H_2O$ | 34 |
| Z ‖ 110 cl. | Fib. | Sm. | Orth. | **Chrysotile** | Sil. | Colorless or yel. to green | 260 |
| Z ⊥ 001 cl. | 001 | 48° | Orth. | *Felsöbányite* | Sul. | G. = 2.33. Sol. HCl | 109 |
| X ⊥ 010 cl. | El. ‖ *c* | 50° | Orth. | *Echellite* | Sil. | Y = *c*. Dec. HCl | 389 |
| Z ⊥ 010 cl. | El. ‖ *c* | 54° | Orth. | Thomsonite | Sil. | Y = *c*. G. = 2.3. Gel. HCl | 382 |
| X ‖ 110 cl. | El. ‖ *c* | 62° | Orth. | Natrolite | Sil. | Y = *b*. Ps. Tet. G. = 2.55. | 390 |
| Z ⊥ 010 cl. | El. ‖ *c* | Mod. | Mon. | *Hydromagnesite* | Carb. | Y ∧ *c* = −43°. G. = 2.16 | 85 |

B. Extinction inclined to elongation or cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z ⊥ 010 cl. | El. ‖ *c* | Mod. | Mon. | *Hydromagnesite* | Carb. | Y ∧ *c* = −43°. G. = 2.16 | 85 |
| Y ⊥ 010 cl. | Prism. | 44° | Mon. | *Epistilbite* | Sil. | Z ∧ *c* = −10°. G. = 2.25 | 396 |
| Y ∧ *c* = 30° | El. ‖ *c* | 60° | Mon. | *Tamarugite* | Sul. | Z = *b*. G. = 2.3. Sol. $H_2O$ | 115 |
| Z ⊥ 010 cl. | El. ‖ *c* | 65° | Mon. | *Brewsterite* | Sil. | X ∧ *c* = +22° ±. Dec. HCl | 397 |
| 001 perf. | El. ‖ *a* | 84° | Mon. | *Petalite* | Sil. | X ∧ *a* = 5°. Z = *b*. G. = 2.4 | 309 |
| Lg. ext. ang. | Prism. | Lg. | Mon. | *Aluminite* (alt.) | Sul. | Dehydrated? G. = 1.77 | 109 |
| Z ∧ *c* = 29° | El. ‖ *c* | Lg. | Mon. | *Dietrichite* | Sul. | X = *b*. Sol. $H_2O$ | 117 |
| Z ∧ *c* = 33° | Fib. | Lg. | Mon. | *Misenite* | Sul. | G. = 2.24. Sol. $H_2O$ | 96 |
| 001, 010 | *a* or 010 | 75° ± | Tr. | **ALBITE** | Sil. | Y ∧ *c* = 7° ±. Z ∧ 010 = 75° ± | 369 |

**Group 23b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z ⊥ 010 cl. | Prism. | 60° ± | Orth. | **Cordierite** | Sil. | Ps. Hex. twin. X = *c*. Colorless or X = yel., Y = blue, Z = blue | 307 |
| 110, 001 | Prism. | 70° | Orth. | *Sulfoborite* | Bor. | X = *c*. Y = *b*. G. = 2.4 | 120 |
| Z = *c* | Fib. | Var. | Orth. | Sepiolite | Sil. | G. = 2.0. Sol. HF | 410 |
| No cleav. | Mass. | Lg. | ? | *Racewinite* | Sil. | G. = 1.96 ±. Green to brown | 433 |

TABLE II.—BIREFRINGENCE OF MINERALS

III. BIREFRINGENCE MODERATE: $N_g - N_p > 0.0095 < 0.0185$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 23b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically −, *continued* | | | | | | | |
| A. No visible cleavage—*continued* | | | | | | | |
| $Y \perp 010$ cl. | ? | 80°± | Mon. | *Didymolite* | Sil. | $X \wedge c = 40°$. G. = 2.7 | 428 |
| ? | Prism. | Mod. | Tr. | *Siderotil* | Sul. | Bl.-green. G. = 2.2 | 107 |
| ? | ? | Mod. | Tr. | *Co-chalcanthite* | Sul. | G. = 2.2 Sol. $H_2O$ | 107 |
| B. One or more visible cleavages | | | | | | | |
| 0001 perf. | 0001 | 0° | Hex. | *Hydrotalcite* | Carb. | G. = 2.06. Sol. HCl | 87 |
| $10\bar{1}0$ perf. | Acic. | 0° | Hex. | *Ettringite* | Sul. | G. = 1.79. Sol. HCl | 115 |
| $X \perp 0001$ cl. | 0001 | 0° | Rhom. | *Gyrolite* | Sil. | G. = 2.4. Also biax.? | 408 |
| $Y \perp 010$ cl. | El. $\parallel c$ | 44° | Orth. | *Stellerite* | Sil. | $X = c$. G. = 2.12 | 389 |
| $Y \perp 100$ cl. | Prism. | 40° | Orth. | *Epidesmine* | Sil. | $X = c$. G. = 2.16 | 388 |
| $Y \perp 010$ cl. | El. $\parallel c$ | 33° | Mon. | Stilbite | Sil. | $X \wedge c = 5°$. G. = 2.2 | 395 |
| $Y \perp 010$ cl. | Prism. | 25° | Mon. | Laumontite | Sil. | $Z \wedge c = -27°$. G. = 2.3 | 391 |
| 110, 100 | Prism. | 28° | Mon. | *Syngenite* | Sul. | $Y \wedge c = -3°$. $Z = b$. G. = 2.6 | 111 |
| 010 perf. | Fib. | Lg. | Tr. | *Okenite* | Sil. | $Z = c \pm$. G. = 2.3. Gel. HCl | 413 |
| **Group 24a.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically + | | | | | | | |
| A. No visible cleavage and no marked elongation | | | | | | | |
| $Z = c$ | Pyr. | 0° | Tet. | *Soumansite* | Phos. | G. = 2.87. Also biax. | 151 |
| $Z = c$ | Prism. | 0° | Tet. | *Pinnoite* | Bor. | G. = 2.29. Sol. HCl | 92 |
| 0001 dist. | 0001 | 0° | Rhom. | *Natroalunite* | Sul. | G. = 2.6 | 114 |
| ? | ? | 0°? | Rhom. | *Loewigite* | Sul. | G. = 2.58 Sign ? | 114 |
| $X = b$. $Y = c$ | ? | Mod. | Orth. | *Grothine* | Sil. | G. = 3.1. Sol. $H_2SO_4$ | 432 |
| $Z \wedge c = -22°$ | ? | 26° | Mon. | *Wagnerite* | Phos. | $Y = b$. G. = 3.0 | 134 |
| $Z \perp 010$ cl. | 010 | 32° | Tr. | *Vauxite* | Phos. | $X' \wedge c = -27°$. Blue: $X = Z < Y$ | 157 |

B. No visible cleavage, but marked elongation

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z ‖ fib. | Fib. | Sm. | Orth. | **Chrysotile** | Sil. | Colorless or yel. to gr. | 260 |
| Z ‖ fib. | Fib. | Sm. | Orth. | *Deweylite* | Sil. | Colorless or yel. to gr. | 261 |
| Z = c | Fib. | Mod. | Orth. | *Barrandite* | Phos. | G. = 2.6. Sol. HCl | 140 |
| X ‖ 110 cl. | Fib. | 75° | Orth. | *Elpidite* | Sil. | G. = 2.58 | 400 |

C. One visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z ‖ fib. | Fib. | Sm. | Orth. | *Xonotlite* | Sil. | One cleav. ‖ elong. | 409 |
| X ⊥ 010 cl. | El. ‖ c | 50° | Orth. | *Echellite* | Sil. | Y = c. Dec. HCl | 389 |
| Z ⊥ 010 cl. | El. ‖ c | 54° | Orth. | Thomsonite | Sil. | Y = c. G. = 2.3. Gel. HCl | 387 |
| Z ⊥ 001 cl. ± | Ps. Hex. | Sm. | Mon. | Amesite | Sil. | Y = b. G. = 2.8 | 285 |
| Z ⊥ 001 cl. ± | Ps. Hex. | Sm. | Mon. | *Sheridanite* | Sil. | Y = b. G. = 2.7 | 283 |
| Z ⊥ 001 cl. ± | Ps. Hex. | Sm. | Mon. | Corundophilite | Sil. | Y = b. G. = 2.9 | 283 |
| Y ⊥ 010 cl. | Acic. | 50° | Mon. | *Isoclasite* | Phos. | Z ∧ c = Sm. G. = 2.9 | 137 |
| 001, 110 | Gran. | 60° | Mon. | *Custerite* | Sil. | X = b. Z ∧ c = 7°. G. = 2.9 | 412 |
| 010, 100 | El. ‖ c | Mod. | Mon. | *Hydromagnesite* | Carb. | Y ∧ c = −43°. Z = b. 100 twin. | 85 |

D. Two or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 at 56° | Prism. | 80° ± | Orth. | **Anthophyllite** | Sil. | X = a. Z = c. Colorless or X, Y = brown Z = yellow or green | 240 |
| 110, $\bar{1}01$ | Var. | 51° | Mon. | *Augelite* | Phos. | Y = b. Z ∧ c = −34°. G. = 2.7 | 143 |
| Z ⊥ 010 cl. | El. ‖ c | Lg. | Mon. | *Brushite* | Phos. | 301 cl. G. = 2.2. | 123 |
| 110 at 56° | Fib. | Lg. | Mon. | *Kuppferite* | Sil. | Y = b. Z ∧ c = −11°. G. = 3.1 | 244 |
| 001, 010 | Prism. | Lg. | Mon. | **Celsian** | Sil. | Y = b. Z ∧ a = +28°. G. = 3.4 | 359 |

**Group 24b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 dist. | Prism. | 0° | Tet. | Dipyre | Sil. | G. = 2.65 ±. Sol. HF | 296 |
| X ⊥ 001 | 0001 | 0° | Hex. | *Metavoltine* | Sul. | X = colorless, Z = orange | 114 |
| X ⊥ 001 | Lam. | 0° | ? | *Saponite* | Sil. | G. = 2.26. Sol. HF | 437 |
| 110, 001 | Prism. | 70° | Orth. | *Sulfoborite* | Bor. | X = c. Y = b. G. = 2.4 | 120 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### III. Birefringence moderate: $N_g-N_p>0.0095<0.0185$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 24b.** Refringence positive and low: $N_o$ or $N_m>1.53<1.59$. Optically −, *continued* | | | |
| | | | | A. No visible cleavage—*continued* | | | |
| Z⊥010 cl. | Prism. | 60°± | Orth. | **Cordierite** | Sil. | Ps. Hex. twin. X=*c*. Colorless or X=yel., Y=blue, Z=blue | 307 |
| X⊥cleav. | ? | Sm. | Orth. | *Centrallasite* | Sil. | G.=2.5. Sol. HCl | 409 |
| X∧*c*=+30° | Lam. | 25° | Mon. | *Morinite* | Phos. | Y=*b*. G.=2.94 | 158 |
| ? | Prism. | Mod. | Tr. | *Siderotil* | Sul. | Bl.-green. G.=2.2. Sol. $H_2O$ | 107 |
| ? | ? | Mod. | Tr. | *Co-Chalcanthite* | Sul. | Pink. G.=2.2. Sol. $H_2O$ | 107 |
| | | | | B. One or more visible cleavage directions | | | |
| X⊥0001 cl. | 0001 | 0° | Hex. | *Pyroaurite* | Carb. | X=colorless, Z=red | 87 |
| X⊥0001 cl. | 0001 | 0° | Rhom. | *Gyrolite* | Sil. | G.=2.4. Also biax.? | 408 |
| X⊥001 cl. | El. ‖ *b* | 68° | Orth. | *Beryllonite* | Phos. | Y⊥100 cl. G.=2.85 | 149 |
| X ‖ 110 cl. | Ps. Tet. | 50°± | Orth. | *Edingtonite* | Sil. | Y=*b*. G.=2.7 | 389 |
| X⊥001 cl. | 001 | Mod. | Mon. | **Antigorite** | Sil. | Y=*b*. G.=2.57 | 280 |
| Z⊥010 cl. | El. ‖ *c* | 79° | Mon. | *Pharmacolite* | Arsen. | X∧*c*=+70°. G.=2.7 | 123 |
| 001 perf. | 001 | ? | Mon. | *Volchonskoite* | Sil. | Bl.-green. G.=2.3 | 416 |
| 010 perf. | Fib. | Lg. | Tr. | *Okenite* | Sil. | X=*c*±. G.=2.3. Gel. HCl | 413 |
| 001, 010 | *a* or 010 | Lg. | Tr. | **BYTOWNITE** | Sil. | Z∧010=42°. Z∧001=45° | 376 |
| 001, 010 | *a* or 010 | Lg. | Tr. | **ANORTHITE** | Sil. | Z∧010=43°. Z∧001=50° | 378 |
| | | | | **Group 25a.** Refringence positive and moderate: $N_o$ or $N_m>1.59<1.66$. Optically + | | | |
| | | | | A. No visible cleavage | | | |
| 110 dist. | Prism. | 0° | Tet. | *Auerlite* | Ox. | Yellow. G.=4.5± | 185 |
| $11\bar{2}0$ dist. | Prism. | 0° | Rhom. | Phenacite | Sil. | G.=3.0. Sol. HF | 185 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Y⊥010 cl. | Prism. | 45°± | Orth. | Mullite | Sil. | Z=*c*. G.=3.0 | 201 |
| Z ∥ fib. | Fib. | Lg. | Orth. | *Salmonsite* | Phos. | 2 cleav. at 90°. G.=2.9. X=colorless, Z=orange | 156 |
| Z⊥100 cl.± | Prism. | 74° | Mon. | *Mosandrite* | Sil. | Y=*b*. G.=3.0 | 423 |
| Z∧*c*=−44° | 010 | 80° | Mon. | *Hellandite* | Sil. | Y=*b*. Brown to red | 425 |
| X⊥010± | Lath. | Lg. | Tr.? | *Uranopilite* | Sul. | Yellow; not pleo. G.=3.9 | 117 |
| | | | | B. One visible cleavage | | | |
| 0001 perf. | 0001 | 0° | Rhom. | *Goyazite* | Phos. | Colorless to br. Also biax. | 153 |
| 0001 perf. | 0001 | 0° | Rhom. | *Svanbergite* | Phos. | G.=3.5. Sol. HCl | 119 |
| Z⊥001 cl. | Ps. Hex. | 15° | Orth. | *Manandonite* | Sil. | G.=2.9. Sol. HF | 95 |
| Z⊥001 cl. | Prism. | 60°± | Orth. | Topaz | Sil. | Y=*b*. G.=3.55 | 198 |
| Z⊥001 cl.± | Ps. Hex. | Sm. | Mon. | Amesite | Sil. | Y=*b*. G.=2.8 | 285 |
| 001 perf. | El. ∥ *b* | 55° | Mon. | *Afwillite* | Sil. | X∧*c*=31°. Y=*b*. G.=2.6 | 412 |
| 001, 110 | Gran. | 60° | Mon. | *Custerite* | Sil. | X=*b*. Z∧*c*=6°. G.=2.9 | 412 |
| 001, 110 | Gran. | 62° | Mon. | ***Cuspidine*** | Sil. | Y=*b*. Z∧*c*=5°. G.=2.96 | 412 |
| X⊥001 cl.± | 001 | Var. | Mon. | *Nontronite* | Sil. | X=yel., Z=yel., gr., br. | 415 |
| 010, 100 | Eq. | Lg. | Tr. | *Fairfieldite* | Phos. | Ext. in 010 at 10° to *c* | 127 |
| | | | | C. Two or more visible cleavage directions | | | |
| 001, 110 | El. ∥ *a* | 38° | Orth. | Barite | Sul. | Y=*b*. Z=*a*. G.=4.5 | 100 |
| Z ∥ 110 cl. | Pyr. | 70° | Orth. | *Stokesite* | Sil. | Y=*b*. G.=3.2 | 409 |
| 110 at 56° | Prism. | 80° | Orth. | **Anthophyllite** | Sil. | Y=*b*. Z=*c*. G.=3± | 240 |
| 110 at 87° | Prism. | 45° | Mon. | **Clinoenstatite** | Sil. | X=*b*. Y∧=*c*+25°±. G.=3.2 | 220 |
| 110 at 87° | Prism. | Sm. | Mon. | **Pigeonite** | Sil. | X or Y=*b*. Z∧*c*=+30°± | 227 |
| 110 at 87° | Prism. | 70°± | Mon. | Jadeite | Sil. | Y=*b*. Z∧*c*=+32°. G.=3.4 | 235 |
| 110 at 56° | Prism. | Lg. | Mon. | *Kupfferite* | Sil. | Y=*b*. Z∧*c*=+11°. G.=3.1 | 244 |

**Group 25b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X=*c* | 0001 | 0° | Hex. | ***Metavoltine*** | Sul. | X=yel., Z=orange. G.=2.5 | 114 |
| X=*c* | Fib. | 0° | Hex. | *Crandallite* | Phos. | H.=4. Decrep. | 154 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### III. Birefringence moderate: $N_g - N_p > 0.0095 < 0.0185$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 25b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically −, *continued* | | | |
| | | | | A. No visible cleavage—*continued* | | | |
| $X = c$ | Fib. | 0° | Hex. | *Dahllite* | Phos. | G. = 3.0. Also biax. | 161 |
| $X = c$ | Prism. | 0° | Hex. | **Tourmaline** | Sil. | Colorless or X = colorless, Z = pink or blue. G. = 3.1 | 301 |
| 110 at 89° | Prism. | 84° | Orth. | **Andalusite** | Sil. | $X = c$. $Y = b$. G. = 3.1–3.2 | 201 |
| X ‖ elong. | Fib. | ? | Orth. | *Koninckite* | Phos. | G. = 2.4. Sol. HCl | 142 |
| $X = c$ | Ps. Hex. | Sm. | Orth. | *Eremeyevite* | Bor. | $c$ ‖ elong. G. = 3.28 | 94 |
| 100? | ? | Lg. | Mon. | *Crestmorite* | Sil. | $Z \wedge$ elong. = 12°. G. = 2.2 | 409 |
| $X \wedge c = 30°$ | El. ‖ $b$ | Lg. | Mon. | **Allanite** | Sil. | X = yel., Y = br., Z = red-br. | 316 |
| 100 dist. | Prism. | 74° | Mon. | *Hureaulite* | Phos. | $X = b$. $Z \wedge c = +75°$. G. = 3.2 | 124 |
| | | | | B. One visible cleavage | | | |
| X⊥001 cl. | Ps. Tet. | 10° | Orth. | *Uranocircite* | Arsen. | X = colorless, Y, Z = yel. G. = 3.5 | 147 |
| X⊥001 cl. | Ps. Tet. | Sm. | Orth. | *Torbernite* | Phos. | X = green, Z = yel. G. = 3.2 | 145 |
| X⊥001 cl. | 001 | 0°± | Mon. | *Ectropite* | Sil. | $Y = b$. $Z = a$±. G. = 2.46 | 409 |
| X⊥001 cl.± | 001 | Sm. | Mon. | *Chamosite* | Sil. | X = yel., Y, Z = green. G. = 3 | 286 |
| X⊥001 cl.± | 001 | Sm. | Mon. | Glauconite | Sil. | X = yel., Y, Z = green. G. = 2.5± | 436 |
| X⊥001 cl.± | 001 | Sm. | Mon. | Celadonite | Sil. | X = yel.-gr., Y, Z = green | 436 |
| X⊥001 cl.± | 001 | Sm. | Mon. | *Seybertite* | Sil. | X = colorless, Y, Z = yel. G. = 3.1 | 286 |
| X⊥001 cl.± | 001 | 20°± | Mon. | *Xanthophyllite* | Sil. | X = brown, Y, Z = green. G. = 3.1 | 286 |
| X⊥001 cl.± | 001 | 25°+ | Mon. | *Brandisite* | Sil. | X = yel., Y, Z = gr. G. = 3.1 | 286 |
| X⊥001 cl.± | 001 | 35° | Mon. | *Margarite* | Sil. | $Z = b$. G. = 3.0–3.1 | 288 |

C. Two or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100, 001 | 100, 001 | 70° | Mon. | **Wollastonite** | Sil. | $X \wedge c = -32°$. $Y = b$. G. = 2.9 | 401 |
| $X \perp 100$ cl. ± | 100 | 49° | Mon. | *Spencerite* | Phos. | $Z \perp 010$ cl. G. = 3.1. Sol. HCl | 137 |
| 110 at 56° | Prism. | 45° ± | Mon. | Glaucophane | Sil. | $Y = b$. $Z \wedge c = +5°$. G. = 3.1. X = colorless, Y = blue, Z = lavender | 258 |

**Group 26a.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically +

A. No visible cleavage and parallel extinction in the chief zones

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z ‖ elong. | Fib. | ? | ? | *Stibiconite* | Ox. | G. = 5.2. Insol. | 68 |
| $Y \perp 010$ cl. | Prism. | 45° + | Orth. | Mullite | Sil. | $Z = c$. G. = 3 | 201 |
| 001, 012 | Prism. | 70° | Orth. | *Barylite* | Sil. | $X = b$. $Y = a$. G. = 4.0 | 401 |
| 010, 100? | Fib. | Lg. | Orth. | *Salmonsite* | Phos. | $Z = c$. X = colorless, Z = orange | 156 |
| $Y = a$? | Ps. Is. | 83° | Orth. | *Boracite* | Bor. | G. = 2.95. Sol. HCl. Isom. above 265° C. | 94 |

B. No visible cleavage and inclined extinction in the chief zones

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X \perp 010$ cl. | Prism. | 23° | Mon. | *Brandtite* | Arsen. | $Y \wedge c = +8°$. G. = 3.6 | 125 |
| 100 dist. | 100 | 43° | Mon. | *Rinkite* | Sil. | $X = b$. $Y \wedge c = -8°$. G. = 3.5 | 423 |
| $Z \perp 100$ cl. ± | 100 | 70° | Mon. | *Johnstrupite* | Sil. | $Y = b$. Lam. twin. G. = 3.3 | 423 |
| $Z \wedge 001$ cl. = 20° | 100 | 85° ± | Mon. | **Clinozoisite** | Sil. | $Y = b$. G. = 3.35. Sol. HF | 312 |
| 001, 011 | El. ‖ *b* | Lg. | Tr. | *Johannite* | Sul. | Green. G. = 3.3 | 118 |
| $Z \perp 010$ cl. ± | Prism. | Lg. | Tr. | *Hainite* | Sil. | Yel.; pleo. G. = 3.2 | 406 |
| 110 at 90° ± | 100 | 90° ± | Tr. | *Guarinite* | Sil. | Yel.; pleo. G.3.3 | 406 |

C. One visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X \perp 001$ cl. | Fib. | Lg. | Orth. | *Pumpellyite* | Sil. | Y ‖ fibers. X, Z = colorless, Y = green | 432 |
| $Y \perp 001$ cl. | Prism. | 65° | Orth. | Lithiophilite | Phos. | $Z \perp 010$ cl. G. = 3.5 | 149 |
| 001, 010 | ? | 72° | Orth. | *Natrophilite* | Phos. | $Y = c$. $Z = b$. Yel. G. = 3.4 | 150 |
| One ‖ elong. | ? | 18° | Mon. | *Lotrite* | Sil. | Green in mass. G. = 3.2 | 433 |
| $Y \perp 001$ cl. ± | 001 | Mod. | Mon. | *Dickinsonite* | Phos. | $X = b$. Olive: X > Y > Z. G. = 3.3 | 122 |
| $Z \perp 001$ cl. ± | 001 | 50° ± | Mon. | ***Sismondine*** | Sil. | $Y = b$ ±. X = gr., Y = bl., Z = yel.-gr. | 438 |
| $Z \perp 010$ cl. | ? | 67° | Mon. | *Merwinite* | Sil. | $X \wedge c = 36°$. G. = 3.15 | 194 |
| $X \perp 100$ cl. ± | ? | Mod. | Tr. | *Roselite* | Arsen. | X, Y = pink, Z = colorless | 127 |
| $Z \perp 001$ cl. ± | 001 | 50° ± | Tr. | Chloritoid | Sil. | Bl.-green; pleo. G. = 3.5 | 438 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### III. Birefringence moderate: $N_g-N_p>0.0095<0.0185$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 26a.** Refringence positive and high: $N_o$ or $N_m>1.66<1.74$. Optically +, *continued* | | | | | | | |
| D. Two or more visible cleavage dirctions | | | | | | | |
| 001, 110 | 001 or *a* | 40°± | Orth. | *Barite (Pb)* | Sul. | $Y=b$. $Z=a$. G.=5± | 100 |
| $X=b$. $Y=c$ | Prism. | Mod. | Orth. | ***Titano-elpidite*** | Sil. | Yellow: X<Y. G.=2.55 | 400 |
| 110 at 88° | Prism. | 70°± | Orth. | **ENSTATITE** | Sil. | $Y=b$. $Z=c$. G.=3.3± | 217 |
| 110 at 87° | Prism. | Sm. | Mon. | **Pigeonite** | Sil. | X or $Y=b$. $Z\wedge c=+30°±$ | 227 |
| 110 at 87° | Prism. | 45°± | Mon. | **Clinoenstatite** | Sil. | $X=b$. $Z\wedge c=+25°$. G.=3.2 | 220 |
| 110 at 87° | Prism. | 60° | Mon. | **Hedenbergite** | Sil. | $Y=b$. $Z\wedge c=48°$. Green: X<Y<Z | 224 |
| 110 at 87° | Prism. | 60°± | Mon. | **Spodumene** | Sil. | $Y=b$. $X\wedge c=+25°±$. Tinted ± | 236 |
| 110 at 87° | Prism. | 70° | Mon. | Jadeite | Sil. | $Y=b$. $Z\wedge c=+30°±$. G.=3.4 | 235 |
| **Group 26b.** Refringence positive and high: $N_o$ or $N_m>1.66<1.74$. Optically − | | | | | | | |
| A. No visible cleavage and uniaxial | | | | | | | |
| X⊥001 cl. | Prism. | 0° | Tet. | **Gehlenite** | Sil. | G.=3.0. Gel. HCl | 209 |
| X⊥001 cl. | Prism. | 0° | Tet. | *Hardystonite* | Sil. | G.=3.4. Gel. HCl | 209 |
| X⊥001 cl. | Prism. | 0° | Tet. | *Justite* | Sil. | G.=3.1. Gel. HCl | 209 |
| $X=c$ | 0001 | 0° | Rhom. | *Melanocerite* | Sil. | G.=4.1. Dec. HCl. Yellow | 420 |
| B. No visible cleavage and biaxial | | | | | | | |
| X ‖ 110 cl. | Prism. | 20° | Orth. | ***Kornerupine*** | Sil. | $Y=a$. G.=3.3 | 421 |
| Z⊥100 cl. | Fib. | 30° | Orth. | Dumortierite | Sil. | Blue; pleo. $Y=b$. G.=3.3 | 422 |
| $X=c$; $Y=b$ | Prism. | Mod. | Orth. | *Kempite* | Hal. | Green. G.=2.9 | 39 |
| One dist. | Prism. | Mod. | Orth. | *Cenosite* | Sil. | Yellow. G.=3.4 | 440 |
| $X=b$; $Y=c$ | Prism. | 75° | Orth. | Monticellite | Sil. | G.=3.2. Gel. HCl | 187 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $Y \wedge c = -2°$ | 100 | 70° | Mon. | *Thalenite* | Sil. | Z=*b*. G.=4.3 | 414 |
| $X \wedge c = 30°$ | El. ‖ *b* | Lg. | Mon. | **Allanite** | Sil. | Green or brown: X<Z | 316 |
| 100 dist. | El. ‖ *b* | 83° | Mon. | *Chlorophoenicite* | Arsen. | Y=*b*. G.=3.5 | 134 |
| $\bar{1}12$, $1\bar{3}0$ | Wedge | 73° | Tr. | **Axinite** | Sil. | X⊥011±. Yel., violet, etc. | 425 |
| X⊥001 cl.± | Ps. Hex. | 83° | Tr. | *Trimerite* | Sil. | G.=3.5. Sol. HCl | 401 |

C. One or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X⊥001 cl. | 001 | 0°± | Tet. | *Sincosite* | Phos. | X=yel., Z=green. G.=2.8 | 147 |
| 110 at 88° | Prism. | 75°± | Orth. | **HYPERSTHENE** | Sil. | X=*a*. Y=*b*. X=red, Y=br., Z=gr. | 219 |
| X⊥001 cl.± | 001 | 20° | Mon. | *Xanthophyllite* | Sil. | X=brown, Y, Z=green. G.=3.1 | 286 |
| X⊥001 cl.± | 001 | 25° | Mon. | *Brandisite* | Sil. | X=yel., Y, Z=green. G.=3.1 | 286 |
| X⊥100 cl.± | 100 | 63° | Mon. | *Tinzenite* | Sil. | Y=*b*. Green: X>Y>Z. | 428 |
| $Z \wedge 001$ cl.=25° | El. ‖ *b* | 80°± | Mon. | **EPIDOTE** | Sil. | Golden: Y>Z>X. G.=3.3 | 314 |
| 110 at 88° | Prism. | Lg. | Mon. | **Clinohypersthene** | Sil. | X=*b*. $Z \wedge c = +30°$±. G.=3.4 | 221 |
| Z⊥010 cl. | Var. | Lg. | Mon. | *Clinohedrite* | Sil. | $Y \wedge c = -28°$. G.=3.3 | 413 |
| 010, 110 | Prism. | 44° | Tr. | *Bustamite* | Sil. | X⊥010±. $Z' \wedge c = 36°$ on 010 | 406 |
| X⊥100 cl.± | El. ‖ *c* | 83° | Tr. | **Kyanite** | Sil. | 100 lam. twin. G.=3.6 | 205 |

**Group 27a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically +

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z ‖ 110 cl. | Prism. | 0° | Tet. | *Thorite* | $ThSiO_4$ | Yellow. G.=5.3 | 185 |
| 111 dist. | Pyr. | 0° | Tet. | Scheelite | $CaWO_4$ | G.=6.1 | 97 |
| 111 dist. | Pyr. | 0° | Tet. | *Powellite* | $CaMoO_4$ | Yellow. G.=4.4 | 98 |
| Z⊥0001 cl. | Prism. | 0° | Hex. | *Nasonite* | Sil. | G.=5.4. Sol. HCl | 407 |
| Z ‖ fib. | Fib. | ? | Orth. | *Stibiconite* | Ox. | G.=5.2. Insol. | 68 |
| Y=*b*. Z=*a* | 100 | 30° | Orth. | *Holdenite* | Arsen. | G.=4. Pink | 136 |
| Y=*b*. Z=*c* | 100 | 55° | Orth. | *Chrysoberyl* | Ox. | Colorless or pleo.; red, gr. | 65 |
| X⊥010 cl. | Prism. | 85° | Orth. | **Staurolite** | Sil. | Z=*c*. Yellow: X<Y<Z | 202 |
| $X \wedge c$=Sm. | 010 | 0°± | Mon. | *Huegelite* | Van. | Z=*b*. Yellow; pleo. G.=5 | 127 |
| No cleav. | Eq. | Mod. | Mon. | *Barthite* | Arsen. | Green. G.=4.2 | 160 |
| $Z \wedge c = +8°$ | Prism. | 85° | Mon. | *Gadolinite* | Sil. | Y=*b*. Gr. or br. G.=4.3 | 424 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### III. Birefringence moderate: $N_g - N_p > 0.0095 < 0.0185$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 27a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically +, *continued* | | | |
| | | | | B. One or more visible cleavage directions | | | |
| 010, 110 | Prism. | 35°± | Orth. | *Ardennite* | Sil. | Y=*b*. Z=*c*. Yellow: X>Y>Z | 440 |
| 001, 110 | Var. | 70°± | Orth. | Anglesite | $PbSO_4$ | Y=*b*. Z=*a*. G.=6.3 | 99 |
| 110 at 87° | Prism. | 60° | Mon. | **Hedenbergite** | Sil. | Y=*b*. Z∧*c*=+48°. Green: X<Y<Z | 224 |
| 110 at 87° | Prism. | 30° | Tr. | *Pyroxmangite* | Sil. | Opt. Pl.⊥010±. G.=3.8 | 406 |
| Z⊥001 cl.± | 001 | 50°± | Tr. | Chloritoid | Sil. | Green, blue; pleo. G.=3.5 | 438 |
| Z⊥001 cl.± | 001 | 50°+ | Tr. | *Sismondine* | Sil. | Green, blue; pleo. G.=3.4 | 438 |
| 110, 1$\bar{1}$0 | Prism. | Lg. | Tr. | Rhodonite | Sil. | G.=3.5. Sol. HF | 403 |
| | | | | **Group 27b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically − | | | |
| X=*c* | 0001 | 0° | Hex. | *Dussertite* | Arsen. | G.=3.75. Sol. HCl. Yel.-green. X<Z | 153 |
| No cleav. | ? | Mod. | Mon. | *Chevkinite* | Sil. | Brown: X<Y<Z. G.=4.5 | 423 |
| | | | | **Group 28a.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically + | | | |
| Z=*c*? | ? | 0° | Tet. | *Strueverite* | Tit. | X=br., Z=gr. to opaque | 164 |
| Z⊥0001 cl. | Prism. | 0° | Hex. | *Iodyrite* | AgI | Yel. Abn. int. colors | 30 |
| | | | | **Group 28b.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically − | | | |
| X=*c*? | ? | 0° | Tet. | *Strueverite* | Tit. | X=gr. to opaque; Z=br. | 164 |
| X=*c* | Prism. | 0° | Hex. | Pyromorphite | Phos. | Colorless or X=yel., Z=gr. | 131 |
| X=*c* | Prism. | 0° | Hex. | *Mimetite* | Arsen. | Colorless or yel.: X<Z | 132 |
| 10$\bar{1}$1 dist. | Prism. | 0° | Hex. | *Finnemanite* | Arsen. | Olive green. G.=7.3 | 159 |
| X=*c* | ? | 0° | Rhom. | *Senaite* | Ox. | Nearly opaque. G.=5.± | 67 |
| X⊥plates | Platy | Sm. | Mon. | *Montanite* | Tel. | Abn. int. colors. G.=3.8 | 109 |

## IV. Birefringence rather strong: $N_g-N_p>0.0185<0.0275$

**Group 29a.** Refringence negative and distinct: $N_o$ or $N_m<1.48$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $Y=b$. $Z=a$ | Ps. Hex. | 70° | Orth. | Carnallite | Hal. | G.=1.6. Sol. $H_2O$ | 34 |
| $Y\perp 001$ cl. | Var. | 83° | Orth. | *Thenardite* | Sul. | $Z=a$. G.=2.7. Sol. $H_2O$ | 96 |

**Group 29b.** Refringence negative and distinct: $N_o$ or $N_m<1.48$. Optically −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X=c$ | Fib. | 0° | ? | *Mendozite* | Sul. | G.=1.7. Sol. $H_2O$ | 113 |
| 100, 110 | Prism. | 40° | Mon. | Borax | Bor. | $X=b$. $Z\wedge c=-55°$. G.=1.7 | 90 |
| ? | Fib. | 48° | Mon. | *Wattevillite* | Sul. | G.=1.8. Sol. HCl | 112 |
| 100 perf. | Prism. | 64° | Mon. | *Creedite* | Sul. | $Y=b$. $Z\wedge c=42°$. Purple ± | 121 |

**Group 30a.** Refringence negative and low: $N_o$ or $N_m>1.48<1.54$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $Z=c$ | ? | 0° | ? | *Ozocerite* | H, C | Also biax. G.=0.9 | 18 |
| $Y=b$. $Z=a$ | Prism. | 78° | Orth. | *Flagstaffite* | H, C, O | G.=1.1. Sol. alcohol | 88 |
| $Y\perp 010$ | 100 | 45° | Orth. | *Newberyite* | Phos. | $Z=c$. G.=2.1. Sol. $HNO_3$ | 123 |
| $Z\perp 010$ cl. | Prism. | 54°± | Orth. | Thomsonite | Sil. | $Y=c$. G.=2.3. Gel. HCl | 387 |
| 101, 010 | Fib. | 72° | Orth. | Wavellite | Phos. | $Y=a$. $Z=c$. G.=2.3. Sol. HCl | 144 |
| $Y\perp 100$ cl. | Acic. | 74° | Orth. | *Tavistockite* | Phos. | $Z=c$. Sol. HCl | 154 |
| $Y\wedge c=23°$ | El. $\parallel c$ | Mod. | Mon. | Ulexite | Bor. | $Z=b$. G.=1.8±. "Cotton balls" | 93 |
| $Z\perp 010$ cl. | El. $\parallel c$ | Mod. | Mon. | *Hydromagnesite* | Carb. | $Y\wedge c=43°$. 100 twin. G.=2.1 | 85 |
| $Z\perp 010$ cl. | Eq. | 35° | Mon.? | *Wapplerite* | Arsen. | $Z=b\pm$. G.=2.5 | 124 |

**Group 30b.** Refringence negative and low: $N_o$ or $N_m>1.48<1.54$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X\perp 001$ cl. | ? | 0° | Tet. | *Loewite* | Sul. | G.=2.4. Sol. $H_2O$ | 111 |
| $X=c$ | ? | 0° | Tet.? | *Bechilite* | Bor. | Doubtful species | 92 |
| $X\perp 0001$ cl. | Var. | 0° | Hex. | *Hanksite* | Sul. | G.=2.56. Sol. $H_2O$ | 119 |
| $X=c$ | Acic. | 0° | Hex. | *Nocerite* | Hal. | G.=2.96 | 38 |
| $X=c$ | 0001 | 0° | Hex. | *Zincaluminite* | Sul. | G.=2.26. Sol. HCl | 115 |
| 100, 110 | Tab. | 85° | Mon. | *Kainite* | Sul. | $X\wedge c=-8°$. $Y=b$. G.=2.13 | 120 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### IV. Birefringence rather strong: $N_g - N_p > 0.0185 < 0.0275$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 30b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically −, *continued* | | | |
| | | | | A. No visible cleavage—*continued* | | | |
| 001 dist. | Tab. | 70° | Mon. | *Inyoite* | Bor. | $X \wedge c = +37°$. $Y = b$. G. = 1.88 | 92 |
| 110 at 73° | 001 | Mod. | Mon. | *Lueneburgite* | Phos. | $Y = b$? $Z \wedge c = 45°$. G. = 2 | 161 |
| ? | Prism. | 60° | Tr. | *Fe-Cu-chalcanthite* | Sul. | Pale blue. G. = 2.1 | 107 |
| | | | | B. One or more visible cleavage directions | | | |
| $10\bar{1}0$ perf. | Prism. | 0° | Hex. | Cancrinite | Sil. | G. = 2.5. Gel. HCl | 301 |
| 0001 perf. | 0001 | 0° | Hex. | *Stichtite* | Carb. | Lilac: $X < Z$. G. = 2.16 | 87 |
| $X \perp 010$ cl. | Acic. | 42° | Orth. | *Morenosite* | Sul. | Greenish. G. = 2 | 103 |
| $X \perp 001$ cl. ± | 001 | Sm. | Mon. | **Antigorite** | Sil. | Greenish. $N_m = 1.57$ usually | 280 |
| 001 perf. | El. ‖ $c$ | 7° | Mon. | Glauberite | Sul. | $X \wedge c = +31°$. $Z = b$. G. = 2.85 | 110 |
| 100 perf. | El. ‖ $c$ | Mod. | Mon. | *Searlesite* | Sil. | $X \wedge c = +30°$. $Z = b$. G. = 2.45 | 423 |
| $X \perp 010$ cl. | El. ‖ $c$ | Lg. | Mon. | *Minasragrite* | Sul. | Blue: $X > Y > Z$. Sol. $H_2O$ | 110 |
| | | | | **Group 31a.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically + | | | |
| | | | | A. No visible cleavage | | | |
| $Z \perp 0001$ cl. | 0001 | 0° | Rhom. | *Alunite* | Sul. | G. = 2.6 | 113 |
| $Z = c$ | Ps. Is. | 0° | Rhom. | *Alumianite* | Sul. | G. = 2.74. Sol. HCl | 107 |
| Z ‖ fib. | Fib. | ? | ? | *Zepharovichite* | Phos. | G. = 2.37. Sol. Cl | 141 |
| Z ‖ fib. | Fib. | Sm. | Orth. | *Xylotile* | Sil. | Yellow: $X = Y < Z$. G. = 2.5 | 261 |
| ? | Mass. | 49° ± | Orth. | *Norbergite* | Sil. | G. = 3.4. Gel. HCl | 196 |
| $Z \perp 100$ ± | 100 | Lg. | Mon. | *Martinite* | Phos. | $Y = b$. G. = 2.9. Sol. HCl | 124 |
| 010 dist. | Prism. | 35° | Tr. | *Paravauxite* | Phos. | On 010 $Y' \wedge c = 38°$ | 157 |

B. One or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Z⊥0001 cl.** | 0001 | 0° | Rhom. | Brucite | $Mg(OH)_2$ | G. = 2.4. Sol. HCl | 42 |
| Z⊥010 cl. | Prism. | 54°± | Orth. | Thomsonite | Sil. | Y = *c*. G. = 2.3. Gel. HCl | 387 |
| 101, 010 | Fib. | 72° | Orth. | Wavellite | Phos. | Y = *a*. Z ‖ fib. G. = 2.33 | 144 |
| **Y⊥001 cl.** | Acic. | 74° | Orth. | *Tavistockite* | Phos. | Z = *c*. Sol. HCl | 154 |
| 001 perf. | 001 | Sm. | Mon. | Gibbsite | $Al(OH)_3$ | X (or Y) = *b*. Z∧*c* = 30°±. G. = 2.35 | 48 |
| 010 perf. | Eq. | 35° | Mon.? | *Wapplerite* | Arsen. | Z = *b*. Ext. on 010 = 20° | 124 |
| **X⊥lam.±** | Lam. | 60° | Tr.? | *Voglite* | Carb. | Z∧elong. = 33°. Lam. twin. | 88 |

**Group 31b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 dist. | El. ‖ *c* | 0° | Tet. | Dipyre | Sil. | G. = 2.65. Sol. HF | 296 |
| X = *c* | ? | 0° | Tet.? | ***Bechilite*** | Bor. | Doubtful species | 92 |
| X = *c* | 0001 | 0° | Hex. | *Zincaluminite* | Sul. | G. = 2.26. Sol. $HNO_3$ | 115 |
| **X ‖ fib.** | Fib. | Sm. | ? | *Ascharite* | Bor. | G. = 2.7 | 92 |
| **Z = *c* ?** | Fib. | 55°± | Orth. | *Variscite* | Phos. | G. = 2.54. Tinted± | 140 |
| **One dist.** | Fib. | ? | Orth. | *Spherite* | Phos. | G. = 2.54 | 144 |
| **110 at 73°** | 001 | Mod. | Mon. | ***Lueneburgite*** | Phos. | G. = 2. Sol. HCl | 161 |
| ? | ? | Mod. | Tr. | *Co-chalcanthite* | Sul. | Pink. G. = 2.2 | 107 |
| ? | ? | 60° | Tr. | *Fe-Cu-chalcanthite* | Sul. | Pale blue. G. = 2.2 | 107 |
| **One dist.** | Fib. | 60° | Tr. | Polyhalite | Sul. | Ext. on cleav. at 20° and 29° | 113 |

B. One visible cleavage and parallel extinction

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **0001 perf.** | 0001 | 0° | Hex. | *Stichtite* | Carb. | Lilac: X<Z. G. = 2.16 | 87 |
| **X⊥001 cl.±** | 001 | 33° | Orth. | *Autunite* | Phos. | X = colorless; Y, Z = yellow | 146 |
| **X±001 cl.±** | 001 | 46° | Orth. | *Uranospinite* | Arsen. | X = colorless; Y, Z = yellow | 147 |
| **X⊥001 cl.±** | 001 | Sm. | Mon. | **Lepidolite** | Sil. | Z = *b*. Colorless, pink, violet | 270 |
| **X⊥001 cl.±** | 001 | 0°± | Mon. | Jefferisite | Sil. | X = colorless; Y, Z = brown | 433 |
| **X⊥001 cl.±** | 001 | Sm. | Mon. | Bowlingite | Sil. | X = yel., Y, Z = gr. or brown | 437 |
| **Z⊥001 cl.±** | 001 | Sm. | Mon. | *Canbyite* | Sil. | Golden br., not pleo. G. = 3± | 415 |
| **X⊥001 cl.±** | 001 | Var. | Mon. | ***Nontronite*** | Sil. | X = yel., Y = olive, Z = gr. G. = 2.5 | 415 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### IV. Birefringence rather strong: $N_g - N_p > 0.0185 < 0.0275$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 31b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically −, *continued* | | | |
| | | | | C. One visible cleavage and inclined extinction | | | |
| X⊥001 cl.± | 001 | Sm. | Mon. | **Lepidolite** | Sil. | Z=*b*. Colorless, pink, violet | 270 |
| 001 perf. | 001 | Sm. | Mon. | Glauberite | Sul. | X∧*c*=+31°. Z=*b*. G.=2.85 | 110 |
| 100 perf. | ? | Mod. | Mon. | *Searlesite* | Sul. | X∧*c*+30°. Z=*b*. G.=2.45 | 423 |
| X⊥010 cl. | 010 | 62° | Mon. | *Bassetite* | Phos. | Yel.: X<Y=Z. G.=3.1 | 146 |
| X⊥010 cl. | El. ‖ *c* | Lg. | Mon. | *Minasragrite* | Sul. | Z∧*c*=12°. Blue: X>Y>Z | 110 |
| X=*b*± | Prism. | 42° | Tr. | *Hannayite* | Phos. | Y∧*c*=33°. G.=1.89 | 151 |
| | | | | **Group 32a.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically + | | | |
| | | | | A. No visible cleavage | | | |
| Z=*c* | ? | 0° | ? | *Plumbogummite* | Phos. | Yellow: X<Z. G.=4.5± | 153 |
| X=*c* | Fib. | Sm. | Orth. | *Roeblingite* | Sil. | G.=3.4. Sol. HCl | 440 |
| Y*b*.=Z=*a*± | 100 | Lg. | Mon.? | *Martinite* | Phos. | G.=2.9. Sol. HCl | 124 |
| Y∧*c*=1°? | 001 | Sm.± | Mon. | *Homilite* (alt.) | Sil. | Yel. G.=3.3±. Sol. HCl | 424 |
| | | | | B. One visible cleavage | | | |
| X⊥010 cl. | ? | Lg. | Orth. | *Kreuzbergite* | Phos. | Y=*c*. G.=2.14 | 141 |
| Y⊥010 cl. | Prism. | 28°± | Orth. | **Sillimanite** | Sil. | Z=*c*. G.=3.25 | 200 |
| Y⊥010 cl. | Prism. | 50°± | Mon. | *Euclase* | Sil. | Z∧*c*=+41°. G.=3 | 432 |
| X⊥001 cl.± | | Lg. | Mon. | *Fremontite* | Phos. | G.=3 | 152 |
| 100 perf. | ? | Lg. | Mon. | *Triplite* | Phos. | Y=*b*. Z∧*a*=42°. Pink to br. | 134 |
| 001, 100 | ? | 80°± | Tr. | Montebrazite | Phos. | G.=3.0. Sol. $H_2SO_4$ | 152 |
| 010 perf. | 100 | 90°± | Tr. | *Parahopeite* | Phos. | X=*a*±. G.=3.3. Sol. HCl | 128 |

C. Two visible cleavages

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 at 76° | Var. | 46° | Orth. | Hemimorphite | Sil. | Y=*a*. Z=*c*. G.=3.45 | 211 |
| 110 at 54° | Fib. | 80°± | Orth. | **Anthophyllite** | Sil. | Y=*b*. Z=*c*. Colorless or tinted | 240 |
| 110 at 56° | Prism. | 60° | Mon. | **Pargasite** | Sil. | Y=*b*. Z∧*c*=+27°. Colorless or X=yel., Y=gr., Z=gr.-blue | 247 |
| 110 at 56° | Prism. | 85°± | Mon. | Cummingtonite | Sil. | Y=*b*. Z∧*c*=+16°. Colorless or X, Y=yel., Z=br. G.=3.2± | 243 |

**Group 32b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X⊥001 cl. | Pyr. | 0° | Tet. | *Meliphanite* | Sil. | Yellow±. G.=3 | 210 |
| X=*c* | Prism. | 0° | Hex. | *Bazzite* | Sil. | X=blue, Z=yel. G.=2.8 | 414 |
| X=*c* | Prism. | 0° | Hex. | Tourmaline (Li) | Sil. | Colorless or yel.: X<Z | 301 |
| X=*c* | Prism. | 0° | Hex. | **Tourmaline(Mg)** | Sil. | Colorless, pink or blue: X<Z | 301 |
| X⊥cleav. | Platy | 30° | Orth. | *Astrolite* | Sil. | X=colorless, Y, Z=gr. G.=2.8 | 429 |
| Z=*c*? | Fib. | Sm. | ? | Chrysocolla | Sil. | X=gr., Z=colorless. G.=2.4± | 411 |
| X⊥001 cl.± | 001 | Sm. | Mon. | *Bityite* | Sil. | G.=3. Sol. HF | 427 |
| Z∧*c*=44° | 100 | Lg. | Mon. | *Howlite* | Bor. | Y=*b*. G.=2.58 | 95 |
| X∧*c*=35°± | El. ‖ *b* | Lg. | Mon. | **Allanite** | Sil. | Brown: X<Y<Z. Sol. HCl | 316 |
| 100 | El. ‖ *b* | 60°± | Tr. | Polyhalite | Sul. | Lam. twin. | 113 |

B. One visible cleavage and uncolored

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z⊥100 cl. | Prism. | 36° | Orth. | α-Hopeite | Phos. | X⊥010 cl. G.=3.0 | 124 |
| X⊥001 cl. | Ps. Tet. | 39° | Orth. | *Leucophanite* | Sil. | Y=*a*. 110 or 001 twin. | 210 |
| X⊥010 cl. | Fib. | 60° | Orth. | *Carpholite* | Sil. | Colorless or yel.: X, Y>Z | 431 |
| Z⊥001 cl. | Platy | 74° | Orth. | *Bertrandite* | Sil. | Y=*b*. G.=2.6 | 410 |
| X⊥100 cl. ± | Platy | 50° | Mon. | *Phosphophyllite* | Phos. | Z=*b*. Y∧*c*=50°±. G.=3. | 125 |
| 001, 110 | Platy | 32° | Tr.? | *Priceite* | Bor. | X∧⊥plate=25°. G.=2.4 | 93 |
| 001, 100 | ? | 50° | Tr. | Amblygonite | Phos. | X in 1$\bar{1}$0. G.=3.1 | 162 |

C. One visible cleavage and colored

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X⊥001 cl. | Ps. Tet. | 0°± | ? | *Zeunerite* | Arsen. | Green: X<Z. G.=3.2 | 146 |
| X⊥001 cl. | 001 | 0°± | Orth. | *Bementite* | Sil. | Brown or gray: X<Y, Z | 409 |

# TABLE II.—BIREFRINGENCE OF MINERALS

## IV. Birefringence rather strong: $N_g - N_p > 0.0185 < 0.0275$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 32b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically −, *continued* | | | | | | | |
| C. One visible cleavage and colored −, *continued.* | | | | | | | |
| X⊥001 cl. | Ps. Tet. | 33° | Orth. | *Autunite* | Phos. | Golden: X<Y=Z. G.=3.1 | 146 |
| X⊥010 cl. | Fib. | 60° | Orth. | *Carpholite* | Sil. | Colorless or yel.: X, Y>Z | 431 |
| X⊥001 cl.± | 001 | Sm. | Mon. | Bowlingite | Sil. | Yel., gr., br.; pleo. G.=3± | 437 |
| X⊥001 cl.± | 001 | Var. | Mon. | *Nontronite* | Sil. | Yel., gr., br.; pleo. G.=2.5 | 415 |
| 001 perf. | 001 | Lg. | Mon. | *Roscherite* | Phos. | X=yel.; Y, Z=br. G.=2.9 | 156 |
| D. Two or more visible cleavage directions | | | | | | | |
| 110 at 55° | Fib. | 80° | Orth. | *Gedrite* | Sil. | Y=*b*. Z=*c*. G.=3.0 | 240 |
| 110 at 56° | Prism. | 43° | Mon. | *Gastaldite* | Sil. | Like glaucophane | 259 |
| 110 at 56° | Prism. | 45°± | Mon. | Glaucophane | Sil. | Y=*b*. Z∧*c*=+5°. G.=3.1. X=yel., Y=violet, Z=blue | 258 |
| 110 at 56° | Prism. | 80°± | Mon. | **HORNBLENDE** | Sil. | Y=*b*. Z∧*c*=+20°±. G.=3.1±. X=yel., Y, Z=gr. or br. | 247 |
| 110 at 56° | Prism. | 80°± | Mon. | **Actinolite** | Sil. | Y=*b*. Z∧*c*=+14°. G.=3.1 | 245 |
| 110 at 56° | Prism. | 85°± | Mon. | **Tremolite** | Sil. | Y=*b*. Z∧*c*=+17°. G=2.9 | 245 |
| **Group 33a.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically + | | | | | | | |
| A. No visible cleavage | | | | | | | |
| Z=*c* | Acic. | 0° | Hex. | *Connellite* | Sul. | Blue±. G.=3.4 | 118 |
| 0001, 11$\bar{2}$0 | Prism. | 0° | Rhom. | Willemite | Sil. | G.=4±. Sol. HCl | 186 |
| 010, 100 | Prism. | Lg. | Orth. | *Shannonite* | Sil. | X=*c*. Y=*a*. | 195 |
| X=*b* | Lam. | 55° | Mon. | *Graftonite* | Phos. | G.=3.67. Sol. HCl | 122 |
| Y∧*c*=−1° | 001 | 80° | Mon. | *Homilite* | Sil. | Z=*b*. Brown±. G.=3.36 | 424 |
| Z∧*c*=+39° | 001 | Lg. | Mon. | *Adelite* | Arsen. | Y=*b*. G.=3.75. Sol. $HNO_3$ | 134 |

B. One or more visible cleavage directions and parallel extinction in chief zones

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z⊥0001 cl. | Rhom. | Sm. | ? | *Hinsdalite* | Sul.+ | G.=4.65. Insol. HCl | 119 |
| Z⊥001 cl. | Pyr. | Sm. | Orth. | *Strengite* | Phos. | Colorless, pink, blue: X,Y<Z | 140 |
| 110 at 55° | Fib. | 80° | Orth. | **Anthophyllite** | Sil. | Y=*b*. Z=*c*. G.=3± | 240 |
| 010, 001 | Prism. | 84° | Orth. | Lawsonite | Sil. | X=*a*. Y=*b*. G.=3.1 | 430 |

C. One or more visible cleavage directions and inclined extinction

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 at 87° | Prism. | 59° | Mon. | **AUGITE** | Sil. | Y=*b*. Z∧*c*=44°±. Colorless± | 228 |
| 110 at 87° | Prism. | 60° | Mon. | **Hedenbergite** | Sil. | Y=*b*. Z∧*c*=47°. Gr.: X<Y<Z | 224 |
| 110 at 87° | Prism. | 6c° | Mon. | **DIOPSIDE** | Sil. | Y=*b*. X∧*c*=42°±. Colorless or Y=brownish; X, Z=greenish | 224 |
| 100 perf. | ? | Lg. | Mon. | *Triplite* | Phos. | Y=*b*. Z∧*c*=42°. Pink, br.: X>Y>Z | 134 |
| 110 at 87° | Prism. | 75°± | Mon. | *Jadeite-diopside* | Sil. | Y=*b*. Z∧*c*=45°±. G.=3.3 | 235 |
| 110 at 55° | Prism. | 85°± | Mon. | Cummingtonite | Sil. | Y=*b*. Z∧*c*=17°±. Yel.: X, Y<Z | 243 |
| 110, 1$\bar{1}$0 | 001 | Mod. | Tr. | Rhodonite | Sil. | G.=3.4±. Sol. HF | 403 |
| 110, 1$\bar{1}$0 | 001 | 41° | Tr. | *Sobralite* | Sil. | X∧*c*=63°. Z∧*c*=46° | 406 |

**Group 33b.** Refringence positive and high: $N_o$ or $N_m>1.66<1.74$. Optically –

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z=*c* | Prism. | 32° | Orth. | *Uranophane* | Sil. | Yellow: X<Y<Z. G.=3.9 | 441 |
| X∧*c*=35° | 100 | Lg. | Mon. | **Allanite** | Sil. | Gr. or br. G.=4± | 316 |
| Z⊥010 cl. | Prism. | 75°± | Mon. | *Woehlerite* | Sil. | Yel.: X, Y<Z. X∧*c*=45°. | 441 |
| Y=*b* | Prism. | Sm. | Mon. | *Chalcomenite* | Sel. | Blue. G.=3.76 | 118 |

B. One visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X⊥001 cl. | Mass. | 0° | Tet.? | *Schallerite* | Sil. | G.=3.37. Sol. HCl | 440 |
| Z⊥001? | ? | ? | ? | *Vilatéite* | Phos. | X=violet, Z=blue. G.=2.75 | 140 |
| Z⊥001 cl. | 001 | Lg. | Orth. | *Gerhardtite* | Nit. | X, Y=gr.; Z=blue. G.=3.4 | 89 |
| X⊥001 cl.± | 001 | 0°± | Mon. | *Strigovite* | Sil. | Green: X<Y, Z. G.=3.1 | 437 |
| 001 perf. | Prism. | 25° | Mon. | *Ganophyllite* | Sil. | X∧*c*=2°. Z=*b*. C.=2.84 | 436 |
| 001 perf. | 001 | 85°± | Mon. | **EPIDOTE** | Sil. | Golden: X<Y. G.=3.3 | 314 |

# TABLE II.—BIREFRINGENCE OF MINERALS

## IV. Birefringence rather strong: $N_g-N_p>0.0185<0.0275$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | **Group 33b.** Refringence positive and high: $N_o$ or $N_m>1.66<1.74$. Optically −, *continued* | | | | | |
| | | C. Two or more visible cleavage directions | | | | | |
| X⊥0001 cl. | Rhom. | 0° | Rhom. | *Hematolite* | Arsen. | Yel. to br. G.=3.4 | 153 |
| 110 at 56° | Prism. | 40°± | Mon. | Barkevikite | Sil. | $Y=b$. $Z<c=12°±$. Brown: X<Y<Z | 254 |
| 110 at 56° | Prism. | 80°± | Mon. | **HORNBLENDE** | Sil. | Yel. to gr. or br. $Z\wedge c=20°±$ | 247 |
| | | **Group 34a.** Refringence positive and very high: $N_o$ or $N_m>1.74<2.00$. Optically + | | | | | |
| Z⊥0001 cl. | Prism. | 0° | Hex. | *Nasonite* | Sil. | G.=5.4. Sol. HCl | 407 |
| Z ‖ fib. | Fib. | Sm. | Orth. | *Conichalcite* | Arsen. | $X=c$. $Y=b$. G.=4.15 | 136 |
| 010 perf. | Prism. | 35°± | Orth. | *Ardennite* | Sil. | $Y=a$. G.=3.6 | 440 |
| Z⊥100 cl. | Prism. | 59°± | Orth. | *Warwickite* | Bor. | Brown: X>Y>Z. G.=3.4 | 95 |
| $Y=b$. $Z=a$ | Prism. | Lg. | Orth. | *Retzianite* | Arsen. | Brown: X<Y<Z. G.=4.15 | 154 |
| ? | ? | ? | ? | *Cervantite* | Ox. | G.=4. Sol. HCl | 67 |
| $Z\wedge c=12°$ | Prism. | 85° | Mon. | *Gadolinite* | Sil. | $Y=b$. G.=4.3±. Sol. HCl | 424 |
| ? | ? | ? | ? | *Chenevixite* | Arsen. | Green. G.=3.9. Sign ? | 156 |
| | | **Group 34b.** Refringence positive and very high: $N_o$ or $N_m>1.74<2.00$. Optically − | | | | | |
| $X=c$ | Prism. | 0° | Hex. | *Cappelenite* | Sil. | Gr.-brown. G.=4.4 | 420 |
| 001, 101 | Dom. | Sm. | Orth. | *Becquerelite* | Ox. | $X=c$. $Y=a$. Yellow: Y<Z | 60 |
| No cleav. | Ps. Hex. | Lg. | Orth. | *Caracolite* | Sul. | 110 twin. | 120 |
| Z⊥001 ? | ? | ? | ? | *Vilatéite* | Phos. | X=violet, Z=blue. G.=2.75 | 140 |
| $\bar{1}01$ dist. | Prism. | 5°± | Mon. | *Allactite* | Arsen. | $X\wedge c=-50°$. $Z=b$. Gr. to yel. | 155 |
| ? | ? | Mod. | Mon. | *Chevkinite* | Sil. | Brown: X<Y<Z. G.=4.5± | 423 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Y⊥010 cl. | Fib. | 65° | Mon. | *Alamosite* | Sil. | G.=6.5. Sol. $HNO_3$ | 401 |
| 001 perf. | 001 | 70°± | Mon. | **EPIDOTE** | Sil. | Y=*b*. Golden: X<Y. G.=3.3± | 314 |
| X∧*c*=35° | 100 | Lg. | Mon. | **Allanite** | Sil. | Brown: X<Y<Z. G.=4.1± | 316 |
| 100 dist. | El. ‖ *b* | 83° | Mon. | *Sarkinite* | Arsen. | Y=*b*. Red to yel. G.=4.2 | 135 |

**Group 35a.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110, 100 | Prism. | 0° | Tet. | *Phosgenite* | Carb. | G.=6.1±. Sol. $HNO_3$ | 85 |
| 0001 perf. | Mass. | 0° | Hex. | Zincite | ZnO | Red. G.=5.5± | 41 |
| Z=*c* | El. ‖ *c* | 0° | Hex. | *Voltzite* | ZnS+ | G.=3.7 | 28 |
| 0001 dist. | Prism. | 0° | Hex. | *Kleinite* | Hal. | Yellow. G.=8 | 38 |
| 10$\bar{1}$0 dist. | Fib. | 0° | Hex. | *Wurtzite* | ZnS | Yellow: X>Z. G.=4 | 20 |
| 10$\bar{1}$0 dist. | Prism. | 0° | Hex. | *Greenockite* | CdS | Yellow. G.=4.8 | 21 |

**Group 35b.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X⊥001 cl. | Ps. Is. | 0° | Tet. | *Boléite* | Hal. | Gr.-blue. G.=5± | 37 |
| X⊥001 cl. | ? | 0° | Tet. | *Lorettoite* | Hal. | Yellow. G.=7.5 | 38 |
| X⊥0001 cl. | Rhom. | 0° | Rhom. | *Barysilite* | Sil. | G.=6.7. Sol. $HNO_3$ | 401 |
| X=*c* | Acic. | 0° | Hex. | *Bellite* | Arsen. | Red or yel.: X<Z. G.=5.5 | 119 |
| One perf. | ? | Var. | Mon.? | *Volborthite* | Van. | Green. G.=3.5 | 137 |
| 001 dist. ? | Prism. | Sm. | Tr.? | *Kleinite* | Hal. | Yellow. G.=7.9± | 38 |

V. BIREFRINGENCE STRONG: $N_g - N_p > 0.0275 < 0.0365$

**Group 36.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically + or −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X ‖ fib. | Fib. | 0°± | ? | *Mendozite* | Sul. | G.=1.7. Sign − | 113 |
| X⊥010 cl. | Fib. | 46° | Orth. | *Goslarite* | Sul. | Y=*c*. G.=2. Sign − | 104 |
| 010, 011 | Prism. | 52° | Orth. | Epsomite | Sul. | X=*b*. Y=*c*. G.=1.68. Sign − | 103 |
| Y∧*c*=13° | Fib. | 52° | Mon.? | Kalinite | Sul. | Z=*b*. G.=1.75. Sign − | 113 |
| 100, 001 | El. ‖ *b* | 90°± | Mon. | *Kernite* | Bor. | Z=*b*. G.=1.95. Sign −? | 90 |

**Group 37a.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Y∧*c*=23° | Fib. | Mod. | Mon. | Ulexite | Bor. | Z=*b*. Cottony. | 93 |
| X⊥010 cl. | Acic. | 70°± | Mon. | *Bobierrite* | Phos. | Z∧*c*=30°±. G.=2.4. | 125 |
| Y∧*c*=10° | Fib. | 79° | Mon. | *Bischofite* | Hal. | X=*b*. G.=1.6. | 32 |

TABLE II.—BIREFRINGENCE OF MINERALS

V. BIREFRINGENCE STRONG: $N_g - N_p > 0.0275 < 0.0365$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 37b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically − | | | |
| $X = c$ | Pyr. | 0° | Tet. | *Mellite* | Mel. | G. = 1.6. Sol. $HNO_3$. | 88 |
| $X = c$ | Acic. | 0° | Hex. | *Thaumasite* | Sul. | G. = 1.87. Sol. HCl. | 119 |
| $10\bar{1}0$ perf. | Prism. | 0° | Hex. | Cancrinite | Sil. | G. = 2.5. Gel. HCl. | 301 |
| $X \perp 0001$ cl. | 0001 | 0° | Hex. | *Brugnatellite* | Carb. | Pink. G. = 2±. | 87 |
| $X \perp 001$ cl. | 001 | 69° | Orth. | *Uranospathite* | Phos. | Y = b. Yel.: $X < Y$, Z. | 146 |
| 110 poor | Var. | 56° | Tr. | Chalcanthite | Sul. | Bluish. G. = 2.2. | 106 |
| | | | | **Group 38a.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically + | | | |
| 110 perf. | 001 | 0° | Tet. | *Narsarsukite* | Sil. | Colorless or yel., $X < Z$. G. = 2.8 | 429 |
| $X = a$. $Y = b$ | Prism. | 55°± | Orth. | *Metavariscite* | Phos. | X = colorless; Y, Z = gr. | 141 |
| X ‖ fib. | Fib. | Lg. | ? | *Tengerite* | Carb. | Sol. HCl | 86 |
| $X \perp 001$ cl. | 001 | 25°± | Mon. | *Cookeite* | Sil. | G. = 2.7 | 435 |
| $Z \perp 010$ cl. | Prism. | 41° | Mon. | *Botryogen* | Sul. | X = yel., Y = red, Z = orange | 116 |
| $X \perp 010$ | 010 | 60° | Mon. | *Hoernesite* | Arsen. | $Z \wedge c = 31°$. G. = 2.6 | 125 |
| $X = c$ | $Y = b$ | Lg. | ? | *Catapleite* | Sil. | G. = 2.66. Also monoclinic | 400 |
| | | | | **Group 38b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically − | | | |
| | | | | A. No visible cleavage | | | |
| $X = c$ | Pyr. | 0° | Tet. | *Mellite* | Mel. | G. = 1.6. Sol. $HNO_3$ | 88 |
| 100 dist. | Prism. | 0° | Tet. | Mizzonite | Sil. | G. = 2.7±. Dec. HCl | 297 |
| 110 poor | Var. | 56° | Tr. | Chalcanthite | Sul. | Bluish. G. = 2.2 | 106 |
| | | | | B. One visible cleavage | | | |
| 0001 perf. | 0001 | 0° | Hex. | *Brugnatellite* | Carb. | Pink. G. = 2± | 87 |
| 0001 perf. | 0001 | 0° | Hex. | *Connarite* | Sil. | Green. G. = 2.5 | 280 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0001 | 0001 | 0° | Hex.? | *Parsettensite* | Sil. | Yellow: X>Y>Z. G.=2.7 | 407 |
| X⊥001 cl. | 001 | Sm. | ? | **Talc** | Sil. | G.=2.75. Sol. HF | 262 |
| X⊥001 cl.± | Ps. Hex. | 0°± | Mon. | *Nepouite* | Sil. | G.=3.1±. Sol. HCl | 279 |
| X⊥001 cl.± | Ps. Hex. | 0°± | Mon. | **BIOTITE** | Sil. | Y=*b*. Br. or gr.: X<Y =Z | 272 |
| X⊥001 cl.± | Ps. Hex. | Sm. | Mon. | **Phlogopite** | . Sil. | Y=*b*. Colorless or br.: X<Z | 272 |
| X⊥001 cl.± | Ps. Hex | 25°± | Mon. | **Zinnwaldite** | Sil. | Z=*b*. Brown: X<Y=Z | 270 |
| X⊥001 cl.± | Ps. Hex | 30°± | Mon. | **Lepidolite** | Sil. | Z=*b*. Colorless, pink, violet | 270 |
| X⊥001 cl.± | Ps. Hex | 45°± | Mon. | **MUSCOVITE** | Sil. | Z=*b*. G.=2.8. Sol. HF | 267 |
| X⊥001 cl.± | Ps. Hex | Mod. | Mon. | Leverrierite | Sil. | Y=*b*. G.=2.5–2.6 | 433 |

**Group 39a.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically +

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 010 dist. | Pyr. | 41° | Orth. | *Reddingite* | Phos. | X=colorless, Y=br., Z=yel. | 124 |
| ‖ ext. | ? | 58° | Orth. | *Cebollite* | Sil. | G.=2.96. Alter. of melilite | 431 |
| Z⊥001 cl. | 001 | 67°± | Orth. | Prehnite | Sil. | Y=*b*. G.=2.9. Lam. twin. | 430 |
| Z=*c* | El. ‖ *c* | Lg. | Orth. | *Barrandite* | Phos. | Tinted±. G.=2.6± | 140 |
| 010, 001 | Var. | 85° | Orth. | **Forsterite** | Sil. | X=*b*. Y=*c*. G.=3.2 | 188 |
| X∧*c*=28° | 010 | 75°± | Mon. | Chondrodite | Sil. | Z=*b*. Colorless or yel.-gr. | 196 |

B. One or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z⊥001 cl. | 001 | 0°± | ? | *Churchite* | Phos. | G.=3.1. Sol. HCl | 156 |
| 110, 010 | Ps. Hex. | 25°± | Mon. | *Catapleite* | Sil. | Y=*b*. Z=*c*±. G.=2.75 | 400 |
| X⊥010 cl. | Prism. | 55° | Mon. | *Colemanite* | Bor. | Z∧*c*=83°. G.=2.4 | 93 |
| 110 at 55° | Fib. | 85°± | Mon. | Cummingtonite | Sil. | Y=*b*. Z∧*c*=17°±. Yel.: **X, Y<Z** | 243 |
| 100, 001 | El. ‖ *b* | 48° | Tr. | *Schizolite* | Sil. | Y∧*a*=9°. Z∧*b*=Sm. G.=3± | 420 |
| One cl. | 100 | Mod. | Tr. | *Messelite* | Phos. | Ext. on 100 at 20° from *c*. | 128 |

**Group 39b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically –

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 dist. | Prism. | 0° | Tet. | Mizzonite | Sil. | G.=2.7± | 297 |
| Y⊥100 cl. | Prism. | 40° | Orth. | *Eosphorite* | Phos. | X=*b*. X=yel., Y=pink, Z=colorless | 156 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### V. Birefringence strong: $N_g - N_p > 0.0275 < 0.0365$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 39b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically −, *continued* | | | | | | | |
| A. No visible cleavage—*continued* | | | | | | | |
| $Z = c$ | Pyr. | 55°± | Orth. | *Variscite* | Phos. | G. = 2.54. Also fibrous | 140 |
| $X \wedge c = -10°$ | Pyr. | 69° | Mon. | Lazulite | Phos. | $Y = b$. X = colorless; Y, Z = blue | 154 |
| $Z \wedge c = -3°$ | Dom. | 74° | Mon. | *Herderite* | Phos. | $Y = b$. G. = 3.0. Sol. HCl | 134 |
| X⊥010 cl. | Mass. | 82° | Mon. | *Tilasite* | Arsen. | $Z \wedge c = -30°$. G. = 3.8 | 134 |
| B. One or more visible cleavage directions and colorless | | | | | | | |
| X⊥0001 cl. | 0001 | 0° | Hex. | *Friedelite* | Sil. | G. = 3.1. Gel. HCl | 408 |
| 110, 010 perf. | ? | Lg. | Orth. | *Catapleite* | Sil. | $X = c$. $Y = b$. G. = 2.66 | 400 |
| X⊥001 cl. | 001 | Sm. | ? | **Talc** | Sil. | $Z = b$. G. = 2.75 | 262 |
| X⊥001 cl.± | Ps. Hex. | 25°± | Mon. | *Kryptotile* | Sil. | $Y = b$. G. = 2.5±. Sol. $H_2SO_4$ | 421 |
| X⊥001 cl.± | Ps. Hex. | 25°± | Mon. | Leverrierite | Sil. | $Y = b$. Colorless or brown | 433 |
| X⊥001 cl.± | Prism. | 25° | Mon. | *Ganophyllite* | Sil. | $Z = b$. X = yel., Y, Z = colorless | 436 |
| X⊥001 cl.± | Ps. Hex. | 45°± | Mon. | **MUSCOVITE** | Sil. | $Z = b$. G. = 2.8. Sol. HF | 267 |
| X⊥010 cl.± | Prism. | 60° | Tr. | *Inesite* | Sil. | G. = 3. Sol. HCl | 413 |
| C. One or more visible cleavage directions and colored | | | | | | | |
| X⊥001 cl. | 001 | 0°± | ? | *Bementite* | Sil. | Yel.; X < Y = Z | 409 |
| X⊥001 cl.± | Ps. Hex. | 0°± | Mon. | *Nepouite* | Sil. | $Y = b$. X = gr.; Y, Z = gr.-yel. | 279 |
| X⊥001 cl.± | Ps. Hex. | 0°± | Mon. | *Connarite* | Sil. | Yel.−gr. G. = 2.5 | 280 |
| X⊥001 cl.± | Ps. Hex. | 25°± | Mon. | Leverrierite | Sil. | $Y = b$. Colorless or brown | 433 |
| X⊥001 cl.± | Ps. Hex. | 25°± | Mon. | **Zinnwaldite** | Sil. | $Z = b$. X = colorless; Y, Z = br. | 270 |
| X⊥001 cl.± | Prism. | 25°± | Mon. | *Ganophyllite* | Sil. | $Z = b$. X = yel.; Y, Z = colorless | 436 |
| X⊥001 cl.± | 001 | Var. | Mon.? | *Nontronite* | Sil. | Br. or gr.; pleo. G. = 2.5 | 415 |

**Group 40a.** Refringence positive and high: $N_o$ or $N_m>1.66<1.74$. Optically +

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **0001, 11$\bar{2}$0** | Prism. | 0° | Hex. | Willemite | Sil. | G.=4±. Sol. HCl | 186 |
| **Z ∥ 110 cl.** | ? | 71° | Orth. | *Manganandalusite* | Sil. | X=yellow, Y=green, Z=yellow | 202 |
| **X⊥010 cl.** | Var. | 90°± | Orth. | **CHRYSOLITE** | Sil. | Y=*c*. G.=3.3. Gel. HCl | 189 |
| **X⊥010 cl.** | Fib. | 90°± | Orth. | *Liskeardite* | Arsen. | Z=*c*. G.=3.0 | 142 |
| **X∧*a*=7°** | Var. | 62° | Mon. | *Titanclinohumite* | Sil. | Z=*b*. X=reddish; Y, Z=orange | 198 |
| **X∧*c*=9°** | Var. | 76° | Mon. | Clinohumite | Sil. | Z=*b*. Colorless or yellowish | 197 |
| **010 dist.** | Prism. | 69° | Tr. | *Spodiosite* | Phos. | Ext. on 010 at 38° | 135 |

B. One visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Z⊥001 cl.** | Pyr. | 20°± | Orth. | *Strengite* | Phos. | Colorless or pink; X, Y<Z | 140 |
| **Y⊥100 cl.±** | Prism. | 28° | Mon. | *Molengraafite* | Sil. | X=*b*. Yellow: Y<X<Z | 418 |
| **001 perf.** | Prism. | 60° | Mon. | *Rosenbuschite* | Sil. | X=*b*. Z∧*c*=−13°. Yel.: X<Y<Z | 419 |
| **Y⊥010 cl.** | Prism. | 62° | Mon. | *Phosphosiderite* | Phos. | X∧*a*=4°. Colorless or pink: X>Y>Z | 142 |
| **001 perf.** | 001 | 70°± | Mon. | *Piedmontite* | Sil. | X∧*c*=−7°. Y=*b*. Yel. to red | 315 |

C. Two or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **110 at 87°** | Prism. | 60° | Mon. | **DIOPSIDE** | Sil. | Y=*b*. Z∧*c*=40°±. G.=3.3 | 224 |
| **110 at 87°** | Prism. | 60° | Mon. | Aegirinaugite | Sil. | Y=*b*. Z∧*c*=70°±. Yel. to gr. | 232 |
| **110 at 87°** | Prism. | 62°± | Tr. | Babingtonite | Sil. | X=gr., Y=br., Z=br. or gr. | 428 |

**Group 40b.** Refringence positive and high: $N_o$ or $N_m>1.66<1.74$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **X=*c*** | Prism. | 0° | Rhom. | **Tourmaline (Fe)** | Sil. | Max. absorp. ⊥ elong. | 301 |
| **Y=*b*. Z=*c*** | Prism. | ? | Orth. | *Soddite* | Ox. | Yellow. G.=4.6 | 61 |
| **Y⊥100 cl.** | Prism. | 40° | Orth. | *Eosphorite* | Phos. | X=*b*. X=yel., Y=pink, Z=white | 156 |
| **X⊥010 cl.** | Fib. | 60° | Orth. | *Liskeardite* | Arsen. | Z=*c*. G.=3.0 | 142 |
| **X⊥100** | 100 | 65° | Orth. | *Erythrosiderite* | Hal. | X, Z=br., Y=red-yel. G.=2.3 | 35 |
| **X⊥010 cl.** | 100 | 85°± | Orth. | **Forsterite** | Sil. | Y=*c*. G.=3.2. Gel. HCl | 188 |
| **Y⊥001 cl.** | 100 | 85°± | Orth. | *Picrotephroite* | Sil. | X=*b*. Gel. HCl | 194 |

TABLE II.—BIREFRINGENCE OF MINERALS

V. BIREFRINGENCE STRONG: $N_g - N_p > 0.0275 < 0.0365$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 40b.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically −, *continued* | | | |
| | | | | B. One or more visible cleavage directions | | | |
| 0001 perf. | 0001 | 0° | Hex. | *Friedelite* | Sil. | White or pink. G. = 3.1 | 408 |
| 0001 perf. | 0001 | 0° | Hex. | *Pyrosmalite* | Sil. | Tinted ±. G. = 3.1 | 408 |
| 0001 perf. | 0001 | 0° | Hex. | *Palmierite* | Sul. | G. = 4.5. Sol. $HNO_3$ | 110 |
| X⊥001 cl. | 001 | 36° | Orth. | *Tyrolite* | Arsen. | X = *c*. Y = *b*. Green: X, Z > Y | 161 |
| X⊥lam. | Lam. | Lg. | Orth. | *Trichalcite* | Arsen. | Y ‖ elong. Bl.-green | 124 |
| X⊥cleav. | ? | Lg. | Orth. | *Sicklerite* | Phos. | Yellow: X > Y > Z. G. = 3.45 | 158 |
| X⊥010 | Ps. Tet. | 0°± | Mon.? | *Phosphuranylite* | Phos. | Yellow: X < Y, Z. Sol. HCl | 147 |
| Z⊥001 cl. ± | Pyr. | Mod. | Mon. | *Hodgkinsonite* | Sil. | Y = *b*. Pink or br. G. = 3.9 | 412 |
| X⊥010 cl. | 010 | 50° | Mon. | *Schroeckingerite* | Carb. | Z∧*c* − 41°. Yel.: X < Y, Z | 86 |
| 110 at 56° | Prism. | Lg. | Mon. | **OXYHORNBLENDE** | Sil. | Y = *b*. Z∧*c* = 1°–10°. G. = 3.4. X = yel. Y, Z = br. or gr. | 252 |
| X⊥010 cl. | ? | 82° | Mon. | *Tilasite* | Arsen. | Z∧*c* = 30°. G. = 3.8 | 134 |
| | | | | **Group 41a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically + | | | |
| 0001, 10$\bar{1}$0 | Prism. | 0° | Hex. | *Ganomalite* | Sil. | G. = 5.6. Gel. HCl | 407 |
| Z ‖ fib. | Fib. | ? | ? | *Cervantite* | Ox. | G. = 4. Sol. HCl. Sign? | 67 |
| 110 | Acic. | ? | Orth. | *Carminite* | Arsen. | Red. G. = 4.1. Sol. $HNO_3$ | 154 |
| ? | Gran. | 26° | ? | *Törnebohmite* | Sil. | X = yel., Y = gr., Z = pink. G. = 4.9 | 414 |
| 110, 010 | ? | 41° | Orth. | *Caryinite* | Arsen. | X = *c*. Y = *a*. Brown | 122 |
| X = *b*. Y = *a* | Pyr. | 50° | Orth. | *Lossenite* | Sul. + | Red. Sol. HCl | 120 |
| X = *b*. Y = *a* | Var. | 65°± | Orth. | Scorodite | Arsen. | Colorless or X = gr., Z = pink. Gr. = 3.2± | 139 |
| Y⊥100 cl.± | Prism. | 28° | Mon. | *Molengraafite* | Sil. | X = *b*. Yel.: X, Z > Y | 418 |
| Z∧*c* = 10° | Prism. | 85° | Mon. | *Gadolinite* | Sil. | Y = *b*. Gr. or br. | 424 |
| No cleav. | Eq. | 90°± | Mon. | *Barthite* | Arsen. | Colorless or green. G. = 4.2 | 160 |

**Group 41b.** Refringence positive and very high: $N_o$ or $N_m>1.74<2.00$. Optically −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0001 perf. | 0001 | 0° | Rhom. | *Nordenskioeldite* | Bor. | Yellow. G.=4.2 | 95 |
| Z⊥001 cl. | Prism. | Sm. | Orth. | Ilvaite | Sil. | X=yel., br., Y=br., Z=gr. | 431 |
| X⊥010 cl. | Var. | Lg. | Orth. | *Tephroite* | Sil. | Y=*c*. G.=4. Gel. HCl | 194 |
| X⊥001 cl. | Mass. | Lg. | Orth. | *Heterosite* | Phos. | X= br., Y=red, Z=violet | 141 |
| X⊥001 cl.± | Ps. Hex. | 0°± | Mon. | Cronstedtite | Sil. | Y=*b*. X=br. or gr. Y, Z=opaque | 285 |
| X⊥010 cl. | Prism. | Sm. | Mon. | *Melanovanadite* | Van. | Br.: X<Y, Z. G.=3.5 | 102 |
| 001 perf. | 001 | 70°± | Mon. | **EPIDOTE** | Sil. | Y=*b*. Golden: X<Y. G.=3.3± | 314 |
| X⊥cleav. | El. ‖ *b* | 74° | Mon. | *Leucophenicite* | Sil. | G.=3.8. Sol. HCl | 412 |
| X∧*c*=20° | Prism. | 80° | Mon. | *Laavenite* | Sil. | Y=*b*. Yellow: X, Y<Z | 420 |
| X⊥100 cl.± | Prism. | 86° | Mon. | *Dietzeite* | Chr. | Y=*b*. Yellow. G.=3.7 | 121 |

**Group 42.** Refringence positive and extreme: $N_o$ or $N_m>2.00$. Optically + or −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X⊥001 cl. | ? | 0° | Tet. | *Pseudobeléite* | Hal. | Deep blue. G.=4.85. Sign − | 37 |
| One | Fib. | ? | ? | *Cuprotungstite* | Tung. | Green. Sign ? | 105 |
| 100 perf. | 100 | Sm. | Mon. | *Raspite* | Tung. | X∧*c*=Lg. Y=*b*. Yel.: X, Y<Z. Sign + | 101 |

## VI. Birefringence very strong: $N_g-N_p>0.0365<0.0545$

**Group 43.** Refringence negative and distinct: $N_o$ or $N_m<1.48$. Optically + or −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z=*c* | ? | 0° | ? | *Paraffin* | C, H | G.=0.9. Sol. ether. Sign + | 17 |
| 001 dist. | 001 | 60° | Mon. | *Lansfordite* | Carb. | X=*b*. Z∧*c*=Sm. G.=1.73. Sign + | 85 |

**Group 44a.** Refringence negative and low: $N_o$ or $N_m>1.48<1.54$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z ‖ fib. | Fib. | Sm. | ? | *Fibroferrite* | Sul. | Yellow: X, Y<Z. G.=1.86 | 109 |
| X⊥100 cl. | ? | 40° | Orth. | *Uranothallite* | Carb. | Green. Sol. HCl | 88 |
| Y=*a*. Z=*c* | Pyr. | 85° | Orth. | *Fluellite* | Hal. | G.=2.2 | 33 |
| 001 perf. | 100 | 60° | Mon. | *Larderellite* | Bor. | X=*b*. Z∧*c*=+24° | 91 |
| 100, 001 | Var. | 81° | Mon. | *Kaliborite* | Bor. | X=*b*. Z∧*c*=+65°. G.=2.1 | 94 |
| 100, 010 | Fib. | Lg. | Mon. | *Hydroboracite* | Bor. | X∧*c*=31°. Y=*b*. G.=2.0 | 92 |
| 001 perf. | Ps. Mon. | 39° | Tr. | *Ussingite* | Sil. | Z∧⊥001=33°±. G.=2.5 | 439 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### VI. BIREFRINGENCE VERY STRONG: $N_g-N_p>0.0365<0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | **Group 44b.** Refringence negative and low: $N_o$ or $N_m>1.48<1.54$. Optically − | | | | | |
| X=*c* | Acic. | 0° | Hex. | *Thaumasite* | Sul. | G.=1.87 | 119 |
| X⊥001 cl.± | Ps. Hex. | Sm. | Mon.? | Leverrierite | Sil. | Colorless or br.: X<Y, Z | 433 |
| | | **Group 45a.** Refringence positive and low: $N_o$ or $N_m>1.53<1.59$. Optically + | | | | | |
| Z ‖ fib. | Fib. | Sm. | ? | *Fibroferrite* | Sul. | Yellow: X, Y<Z. G.=1.86 | 109 |
| 001, 010 | Var. | 42° | Orth. | Anhydrite | Sul. | Y=*b*. Z=*a*. G.=2.93 | 98 |
| 100, 001 | Fib. | ? | Mon. | *Magnesiopectolite* | Sil. | Z ‖ fib. G.=2.7 | 420 |
| 100, 010 | Fib. | Lg. | Mon. | *Hydroboracite* | Bor. | X∧*c*=31°. Y=*b*. G.=2.0 | 92 |
| | | **Group 45b.** Refringence positive and low: $N_o$ or $N_m>1.53<1.59$. Optically − | | | | | |
| X⊥001 cl.± | 001 | Sm. | ? | **Talc** | Sil. | Z=*b*. G.=2.75± | 262 |
| X⊥001 cl.± | 001 | 56°± | ? | Pyrophyllite | Sil. | G.=2.85± | 263 |
| X⊥001 cl.± | El. ‖ *a* | 90°± | ? | *Janosite* | Sul. | X=yel.-gr., Y=yel., Z=yel. | 108 |
| X⊥001 cl.± | 001 | Sm. | Mon. | *Pholidolite* | Sil. | G.=2.4. Greenish ± | 435 |
| 100 perf. | El. ‖ *c* | Mod. | Mon. | *Jezekite* | Phos. | X∧*c*=+29°. Y=*b*. G.=2.94 | 158 |
| X⊥001 cl.± | 001 | 45°± | Mon. | **MUSCOVITE** | Sil. | Z=*b*. G.=2.8± | 267 |
| | | **Group 46a.** Refringence positive and moderate: $N_o$ or $N_m>1.59<1.66$. Optically + | | | | | |
| | | A. No visible cleavage | | | | | |
| Z=*c* | Fib. | 0° | Hex.? | *Rhabdophanite* | Phos. | G.=4. Sol. HCl | 139 |
| X=*a*. Z=*b* | Tab. | 68° | Orth. | Humite | Sil. | Colorless or yel.: X>Y, Z | 197 |
| Z∧*c*=36° | ? | 38° | Mon. | *Arakawaite* | Phos. | Y=*b*. Green | 138 |
| Z⊥010 cl. | El. ‖ *c* | 77° | Mon. | *Leucosphenite* | Sil. | Y∧*c*=3°. G=3 | 418 |
| ? | Tab. | Sm. | Tr.? | *Destinezite* | Sul. | G.=2.1. Sol. HCl | 121 |
| 1$\bar{1}$0 + one | El. ‖ *c* | 40° | Tr. | *Turquois* | Phos. | Ext. on 1$\bar{1}$0 at 12° to *c*. Blue | 157 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | **B. One or more visible cleavage directions** | | | |
| $10\bar{1}1$ perf. | El. ∥ $c$ | 0° | Rhom. | *Dioptase* | Sil. | Green: X>Z. G.=3.2 | 186 |
| X⊥010 cl. | 010 | 58° | Orth. | *Haidingerite* | Arsen. | Z=$c$. G.=2.85 | 123 |
| 001 dist. | Ps. Hex. | 0°± | Mon.? | *Pseudowollastonite* | Sil. | Z=$c$±. G.=2.9 | 402 |
| 100, 001 | El. ∥ $b$ | 60° | Mon. | Pectolite | Sil. | X=$a$±. Z=$b$. G.=2.8± | 419 |
| 010, 100 | Prism. | 80° | Mon. | Vivianite | Phos. | X=$b$ Z∧$c$=+28°. G.=2.6. X=blue, Y=white, Z=olive | 126 |
| 101, 010 | Fib. | 53° | Tr. | *Anapaite* | Phos. | Ext. on 100 at 15° to $c$. | 128 |
| | | | | **Group 46b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically − | | | |
| | | | | **A. No visible cleavage** | | | |
| X ∥ 100 cl. | Prism. | 0° | Tet. | Meionite | Sil. | G.=2.75±. Dec. HCl | 297 |
| X=$c$ | ? | 0° | Rhom. | *Chloraluminite* | Hal. | Sol. $H_2O$. Deliques. | 33 |
| Y⊥001 cl. | Prism. | Lg. | Orth. | *Sklodowskite* | Sil. | Yellow: X<Y<Z. G.=3.5 | 441 |
| Z∧$c$=−2° | Prism. | 74° | Mon. | Datolite | Sil. | Y=$b$. G.=2.9–3.0. Gel. HCl | 424 |
| | | | | **B. One or more visible cleavage directions** | | | |
| 001, 010 | 001 | 0°± | Tet.? | *Troegerite* | Arsen. | Yellow. G.=3.3. Sol. HCl | 147 |
| X⊥001 cl. | 001 | Sm. | ? | **Talc** | Sil. | G.=2.75±. Sol. HF | 262 |
| X⊥100 cl. | El. ∥ $c$ | 30° | Orth. | *Grandidierite* | Sil. | Y=$c$. Green: Y<X<Z | 421 |
| X⊥001 cl.± | 001 | 0°± | Mon. | *Nepouite* | Sil. | Y=$b$. X=gr.; Y, Z=yel. | 279 |
| X⊥001 cl.± | 001 | 0°± | Mon. | **BIOTITE** | Sil. | Y=$b$. Br. or gr.: X<Y, Z | 272 |
| X⊥001 cl.± | 001 | Sm. | Mon. | Leverrierite | Sil. | Y=$b$. Colorless or br. X<Y, Z | 433 |
| X⊥001 cl.± | 001 | 45°± | Mon. | **MUSCOVITE** | Sil. | Z=$b$. G.=2.8± | 267 |
| X⊥001 cl.± | 001 | Mod. | Mon. | *Fuchsite* | Sil. | Z=$b$. Colorless or gr.: X<Y, Z | 269 |
| | | | | **Group 47a.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically + | | | |
| X=$b$. Y=$a$ | Prism. | 29° | Orth. | *Euchroite* | Arsen. | Green. G.=3.4. Sol. $HNO_3$ | 136 |
| X⊥100 cl. | Tab. | 75°± | Orth. | Iddingsite | Sil. | Z⊥001 cl. Br.: X<Y<Z | 437 |
| Y⊥010 cl. | Prism. | 84° | Orth. | Diaspore | Ox. | Z=$a$. Colorless or br.: X>Z | 46 |
| 101 dist. | El. ∥ $b$ | 88°± | Orth. | *Adamite* | Arsen. | X=$a$. Y=$c$. Colorless or pink | 133 |
| 110 at 80° | Prism. | 49° | Mon. | *Neptunite* | Sil. | Y=$b$. Z∧$c$=+18°. Br.: X<Y<Z | 418 |
| 001 perf. | El. ∥ $b$ | 70° | Mon. | *Piedmontite* | Sil. | X∧$c$=−7°. Y=$b$. X=yel., Y=violet, Z=red | 315 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### VI. Birefringence very strong: $N_g - N_p > 0.0365 < 0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 47a.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically +, *continued* | | | |
| 010 dist. | El. ‖ *c* | 77° | Mon. | *Leucosphenite* | Sil. | $Y \wedge c = +3°$. $Z = b$. 001 twin. | 418 |
| 001, 100 | 001 | 82° | Mon. | *Ludlamite* | Phos. | $Y = b$. $Z \wedge c = -67°$. Green | 137 |
| | | | | **Group 47b.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically − | | | |
| | | | | A. No visible cleavage | | | |
| $X = c$ | Prism. | 0° | Rhom. | *Tourmaline (Cr)* | Sil. | X = yel., Z = gr. G. = 3.1 | 301 |
| $X = b$. $Y = a$ | Prism. | 45° | Orth. | *Childrenite* | Phos. | G. = 3.2±. Sol. HCl | 155 |
| $X = b$. $Y = c$ | Prism. | 61° | Orth. | *Glaucochroite* | Sil. | G. = 3.4. Gel. HCl | 187 |
| X⊥010 cl. | Var. | Lg. | Orth. | *Tephroite* | Sil. | $Y = c$. G. = 4. Gel. HCl | 194 |
| $X = b$. $Y = c$ | Prism. | 85°± | Orth. | **CHRYSOLITE** | Sil. | G. = 3.3. Gel. HCl. (= **OLIVINE**) | 189 |
| 101 dist. | El. ‖ *b* | 88° | Orth. | *Adamite* | Arsen. | $X = a$. $Y = c$. Colorless or pink | 133 |
| 001 dist. | ? | 40° | Mon.? | *Spurrite* | Sil. | $X = b$. $Z \wedge a = 0°±$. G. = 3± | 442 |
| 110 at 70° | Pyr. | 57° | Mon. | *Durangite* | Arsen. | $X \wedge c = -25°$. $Z = b$. Yel.: X > Y > Z | 151 |
| | | | | B. One or more visible cleavage directions | | | |
| X⊥0001 cl. | 0001 | 0°± | Rhom. | *Pyrochroite* | Ox. | Reddish: X < Z | 42 |
| 0001 perf. | 0001 | 0° | Rhom. | *Spangolite* | Sul. | X = bl.-gr., Z = gr. G. = 3.1 | 119 |
| X⊥100 cl. | Tab. | 75°± | Orth. | Iddingsite | Sil. | Z⊥001 cl. Brown: X < Y < Z | 437 |
| X⊥001 cl. | Prism. | Lg. | Orth. | *Schoepite* | Ox. | Yellow: X < Y, Z. G. = 5.7 | 60 |
| X⊥001 cl.± | 001 | 0°± | Mon. | **BIOTITE** | Sil. | $Y = b$. X = yel., Y, Z = br. or gr. | 272 |
| X⊥010 cl. | 010 | 50°± | Mon. | *Schroeckingerite* | Carb. | $Z \wedge c = 41°$. Yel.: X < Y, Z | 86 |
| 110 at 56° | Prism. | 80°± | Mon. | **OXYHORNBLENDE** | Sil. | $Y = b$. $Z \wedge c = 5°±$. G. = 3.4±. X = yel., Y = gr. or br. Z = br.± | 252 |
| 110 at 56° | Prism. | 82°± | Mon. | Grunerite | Sil. | Y = b. $Z \wedge c = 12°$. G. = 3.5±. X, Y = colorless, Z = yel., or gr. | 242 |
| 001 perf. | Var. | 50° | Tr. | *Tarbuttite* | Phos. | Ext. on 010 at 10° to *a* | 135 |

**Group 48a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically +

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $Z=c$ | Prism. | 0° | Tet. | **Zircon** | Ox. | Colorless, br., gray. G.=4.7 | 183 |
| $Z=c$ | Pyr. | 0° | Rhom. | *Benitoite* | Sil. | Tinted±: X<Z | 212 |
| Y ∥ fib.? | Fib. | Sm. | ? | *Cornwallite* | Arsen. | Green. G.=4.1 | 136 |
| X ∥ 120 cl. | Prism. | 39° | Orth. | *Lorenzenite* | Sil. | $Z=b$. G.=3.4 | 400 |
| Y ∥ 110 cl. | Prism. | 67° | Orth. | *Orientite* | Sil. | $X=a$. Br. to yel.: X>Z>Y | 432 |
| Y or $Z=c$ | Acic. | Lg. | Orth. | *Leucochalcite* | Arsen. | Silky white | 136 |
| $Y=c$. $Z=a$ | 001 | Lg. | Orth. | *Flinkite* | Arsen. | X, Y=gr., Z=br. G.=3.87 | 154 |
| $X\wedge c=45°$ | Prism. | Sm. | Mon. | *Synadelphite* | Arsen. | $Z=b$. Br., nearly opaque | 155 |
| $X\wedge c=89°$ | 100 | Mod. | Mon. | *Beraunite* | Phos. | $Z=b$. X, Y=pink, Z=red | 144 |
| $Z\wedge c=45°$ | Fib. | Lg. | Mon.? | *Bayldonite* | Arsen. | $X=b$. Green. G.=4.35 | 137 |

B. One or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X⊥001 cl. | ? | 38° | Orth. | *Purpurite* | Phos. | $Y=a$. X=gray, br., Y=red, Z=purple | 141 |
| Z⊥001 cl. | Lam. | 45°± | Orth. | Iddingsite | Sil. | $X=a$. Red-br., X<Y<Z | 437 |
| Z⊥001 cl.± | El. ∥ $b$ | 16° | Mon. | Monazite | Phos. | $X=b$. Yellow: Y>X, Z | 138 |
| Z⊥010 cl. | Fib. | Sm. | Mon. | *Kraurite* | Phos. | $X=a$±. Br. or gr.: X<Y, Z | 142 |
| 001 perf. | El. ∥ $b$ | 70° | Mon. | *Piedmontite* | Sil. | $X\wedge c=7°$. Y=b. G.=3.5. X=yel., Y=violet, pink, Z=red | 315 |
| 110 at 87° | Prism. | Lg.? | Mon.? | *Jadite-acmite* | Sil. | $Y=b$. $Z\wedge c=85°$. G.=3.5 | 235 |

**Group 48b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X=c$ | 0001 | 0° | Hex. | Beaverite | Sul. | G.=4.36. Sol. HCl | 115 |
| $X=c$ | Rhom. | 0° | Rhom. | *Högbomite* | Ox. | X=yel., Z=br. G.=3.8 | 65 |
| X⊥010 cl. | 100 | 50°± | Orth. | **Fayalite** | Sil. | $Y=c$. Colorless or yellow | 192 |
| X⊥010 cl. | Var. | 55°± | Orth. | *Knebelite* | Sil. | $Y=c$. Colorless or yellow | 193 |
| X⊥010 cl. | Var. | 70°± | Orth. | **OLIVINE** | Sil. | $Y=c$. G.=4±. Gel. HCl | 189 |
| $X=a$. $Y=b$ | Prism. | 90°± | Orth. | *Higginsite* | Arsen. | X=gr., Y=yel.-gr., Z=bl.-green | 132 |
| X⊥010 cl. | ? | 50°± | Mon. | *Pascoite* | Sil. | X, Y=yel., Z=orange | 160 |
| 110 dist. | Prism. | 66° | Mon. | *Thortveitite* | Van. | $X\wedge c=5°$. $Y=b$. X=gr., Y, Z=yel. | 211 |

# TABLE II.—BIREFRINGENCE OF MINERALS

## VI. Birefringence very strong: $N_g - N_p > 0.0365 < 0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 48b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically −, *continued* | | | |
| | | | | B. One or more visible cleavage directions | | | |
| X⊥0001 cl. | 0001 | 0° | Rhom. | *Molybdophyllite* | Sil. | G.=4.7 | 407 |
| X⊥001 cl. | Lam. | Lg. | Orth. | *Heterosite* | Phos. | Y=*a*. X=gray, br., Y=red, Z=violet | 141 |
| X⊥010 cl. | Prism. | 75° | Orth. | *Atacamite* | Hal. | Y=*a*. Green: X<Y<Z | 38 |
| X⊥010 cl. | Fib. | Sm. | Mon. | *Manganostibite* | Antim. | Z∧*c*=Lg. X=red-br., Z=opaque | 155 |
| 001 perf. | 001 | 50° | Mon. | *Hancockite* | Sil. | Y=*b*. X or Z=rose, Y=brown | 316 |
| 110 at 88° | Prism. | 60°± | Mon. | **Acmite** | Sil. | X∧*c*=5°±. Y=*b*. G.=3.5. Brown or green: X>Y>Z | 234 |
| 001 perf. | 001 | 70°± | Mon. | **EPIDOTE** | Sil. | X∧*c*=3°. Y=*b*. G.=3.5. Golden: X<Z<Y | 314 |
| 100 perf. | El. ‖ *b* | 80° | Mon. | *Linarite* | Sul. | X∧*c*=24°. Z=*b*. G.=5.4. Blue: X<Y<Z | 104 |
| | | | | **Group 49a.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically + | | | |
| Z⊥0001 cl. | 0001 | 0° | Rhom. | *Moissanite* | SiC | Tinted±: X>Z | 17 |
| X⊥001 cl. | 100 | 50°± | Orth. | *Pseudobrookite* | Ox. | Z=*a*. Red-br.: X<Y>Z | 165 |
| 001 poor | ? | 4° | Mon. | *Atelestite* | Arsen. | Yellow. G.=6.4 | 143 |
| | | | | **Group 49b.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically − | | | |
| X=*c* | Prism. | 0° | Hex. | *Endlichite* | Van. | Yellow. G.=7 | 132 |
| X=*c* | Var. | 0° | Rhom. | *Langbanite* | Ox. | Brown: X<Z. G.=4.5 | 66 |
| Z=*c* | Fib. | Mod. | ? | *Bismutite* | Carb. | G.=7. Sol. $HNO_3$ | 86 |
| | | | | **VII. Birefringence extreme: $N_g - N_p > 0.0545$** | | | |
| | | | | **Group 50.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically + or − | | | |
| Z=*c* | Fib. | ?° | ? | Chrysocolla | Sil. | Green, etc.: X>Z. G.=2.4. Sign? | 411 |
| X⊥001 cl.± | 001 | 7° | Tr. | *Sassolite* | Ox. | Ext. on 001 at 3°–20° to *a*. Sign − | 50 |

**Group 51a.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z⊥001 cl.? | 001? | Sm. | Orth. | *Hatchettite* | C, H | Fibers have − elong. | 18 |
| Y=*c*. Z=*b* | Prism. | 33° | Orth. | *Pirssonite* | Carb. | G.=2.35. Sol. HCl | 87 |
| X⊥100 cl. | Fib. | 58° | Orth. | *Sideronatrite* | Sul. | Z ‖ fib. Yel.: X<Y, Z | 115 |
| X⊥001 cl. | 001 | 60°± | Orth. | *Copiapite* | Sul. | Y=*b*. X=gr., Z=yel. G.=2.2 | 108 |
| ? | ? | 62°± | Orth. | *Bechilite* | Bor. | Doubtful species | 92 |
| X⊥001 cl. | 001 | 66° | Orth. | *Knoxvillite* | Sul. | Y=*b*. Yellow-green: X, Y<Z | 108 |
| 110 dist. | Prism. | 34° | Mon. | *Quetenite* | Sul. | Orange: X, Y<Z. G.=2.1 | 116 |
| 11$\bar{1}$, 11$\bar{3}$ perf. | Pyr. | 57° | Mon. | Kieserite | Sul. | Y=*b*. Z∧*c*=76°. G.=2.57 | 104 |

**Group 51b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 011 perf. | Acic. | 7° | Orth. | Niter | $KNO_3$ | X=*c*. Y=*a*. G.=2.1 | 89 |
| Y⊥laths | Lam. | 61° | Orth. | *Nitroglauberite* | Nit. | Sol. $H_2O$ | 120 |
| 110 perf. | Acic. | 77° | Orth. | *Dawsonite* | Carb. | X=*a*. Y=*c*. G.=2.4 | 87 |
| Y=*c* | Fib. | Lg. | Orth. | *Artinite* | Carb. | G.=2.0. Sol. HCl | 84 |
| 110? | Fib. | 5° | Mon. | *Nitromagnesite* | Nit. | Sol. $H_2O$ | 89 |
| 100, 010 perf. | 100 | 27° | Mon. | *Darapskite* | Sul. | X=*b*. Z∧*c*=12°. G.=2.2 | 120 |
| 110 perf. | El. ‖ *a* | 34° | Mon. | *Gaylussite* | Carb. | X=*b*. Z∧*c*=14°. G.=1.9 | 87 |
| 100 perf. | El. ‖ *b* | 72° | Mon. | *Trona* | Carb. | X=*b*. Y∧*c*=7°. G.=2.1 | 69 |
| 010 perf. | El. ‖ *c* | 79° | Tr. | *Meyerhofferite* | Bor. | Z⊥010±. G.=2.1 | 93 |

**Group 52a.** Refringence positive and low: $N_o$ or $N_m > 1.54 < 1.59$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Z=*c* | Fib. | 0° | Hex. | *Cacoxenite* | Phos. | Yel. X<Z. G.=3.4 | 143 |
| 10$\bar{1}$0, 0001 | Acic. | 0° | Rhom. | *Ferrinatrite* | Sul. | G.=2.56. Sol. $H_2O$ | 114 |
| X⊥001 cl. | 001 | Sm. | Orth. | *Rhomboclase* | Sul. | Y=*a*. X=red, Y, Z=yel., pink | 108 |
| X⊥001 cl. | 001 | 60°± | Orth. | *Copiapite* | Sul. | Y=*b*. X=gr., Z=yel. G.=2.2 | 108 |
| Z ‖ 110 cl. | Prism. | Lg. | Orth. | *Humboldtite* | Oxal. | Y=*b*. X=gr., Z=yel. "Oxalite" | 88 |
| 010, 100 | Prism. | 87° | Orth. | *Hambergite* | Bor. | X=*a*. Y=*b*. G.=2.35 | 91 |
| 110 dist. | ? | 34° | Mon. | *Quetenite* | Sul. | Yel.: X, Y<Z. G.=2.1 | 116 |
| 11$\bar{1}$, 11$\bar{3}$ perf. | Pyr. | 57° | Mon. | Kieserite | Sul. | Y=*b*. Z∧*c*=76°. G.=2.57 | 104 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### VII. BIREFRINGENCE EXTREME: $N_g-N_p>0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | **Group 52a.** Refringence positive and low: $N_o$ or $N_m>1.54<1.59$. Optically +, *continued* | | | | | |
| 001, 010 + | Var. | 84° | Mon. | *Whewellite* | Oxal. | $X=b$. $Z\wedge c=29°$. G.=2.2 | 89 |
| 001 perf. | El. ‖ *b* | 87° | Mon. | *Fichtelite* | C, H | $Z\wedge c=13°$. Sol. ether | 18 |
| | | **Group 52b.** Refringence positive and low: $N_o$ or $N_m>1.53<1.59$. Optically − | | | | | |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Nitratite* | $NaNO_3$ | G.=2.27. Deliques. | 89 |
| $10\bar{1}1$ poor | Rhom. | 0° | Rhom. | *Trudellite* | Sul. | G.=1.93. Deliques. | 119 |
| X⊥001 cl. | 100 | 62° | Orth. | *Oxammite* | Oxal. | $Y=a$. G.=1.5. Sol. $H_2O$ | 89 |
| X⊥001 cl. | 001 | 62° | Orth. | *Lanthanite* | Carb. | $Y=a$. G.=2.7±. Sol. HCl | 86 |
| $Y=c$ | Fib. | 71° | Orth. | *Artinite* | Carb. | G.=2.0. Sol. HCl | 84 |
| 110 perf. | Acic. | 77° | Orth. | *Dawsonite* | Carb. | $X=a$. $Y=c$. G.=2.4 | 87 |
| ? | ? | Lg. | ? | *Cu-aphthitalite* | Sul. | G.=3? Sol. $H_2O$ | 96 |
| X⊥001 cl.± | 001 | Sm. | Mon. | *Griffithite* | Sil. | X=yel., Z=br.-gr. | 434 |
| 010, 011 perf. | Prism. | 79° | Mon. | *Kroehnkite* | Sul. | $X\wedge c=49°$. $Y=b$. Sol. $H_2O$ | 112 |
| ? | 001 | 51° | Tr. | *Roemerite* | Sul. | Ext. on 101 at 33° to *c* | 117 |
| 010 perf. | El. ‖ *c* | 79° | Tr. | *Meyerhofferite* | Bor. | Z⊥010±. G.=2.1 | 93 |
| | | **Group 53a.** Refringence positive and moderate: $N_o$ or $N_m>1.59<1.66$. Optically + | | | | | |
| X⊥laths | Lath. | Sm. | Orth. | *Bisbeeite* | Sil. | $Z=c$. Colorless or X, Y=br., Z=gr. | 411 |
| Z ‖ fib. | Fib. | Mod. | Orth. | *Planchéite* | Sil. | X⊥cleav. Blue: X, Y<Z | 411 |
| X⊥laths | Lath. | 83° | Orth. | *Kyanotrichite* | Sul. | $Z=c$. Blue: X, Y<Z | 116 |
| 010, 100 | Prism. | 87° | Orth. | *Hambergite* | Bor. | $X=a$. $Y=b$. G.=2.35 | 91 |
| 011 perf. | Pyr. | 37° | Mon. | *Natrochalcite* | Sul. | $Y=b$. $Z\wedge c=12°$. Green | 112 |
| $Z\wedge c=33°$? | ? | 71° | Mon.? | *Vesselyite* | Phos. | $Y=b$? Gr.-blue. G.=3.5 | 138 |
| One perf. | ? | 90°±(art.) | Mon. | *Szmikite* | Sul. | $Z=b$. Pink± | 104 |

**Group 53b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X=*c* | Acic. | 0° | ? | *Szaibelyite* | Bor. | G.=3. Sol. $H_2SO_4$ | 92 |
| Y⊥laths | Lath. | Lg. | Orth. | *Camsellite* | Bor. | X ‖ elong. | 91 |
| Z∧*c*=25° | ? | 67° | Mon. | *Liroconite* | Arsen. | X=*b*. Greenish. G.=2.9 | 157 |
| 010 dist. | Fib. | Lg. | Tr. | *Stewartite* | Phos. | X⊥100±. Yel.: X<Y<Z | 128 |

B. One or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10$\bar{1}$1 perf. | Var. | 0° | Rhom. | **CALCITE** | $CaCO_3$ | G.=2.71. Sol. HCl | 71 |
| X⊥0001 cl. | 0001 | 0° | Rhom. | *Chalcophyllite* | Arsen. | Green. G.=2.5 | 136 |
| X⊥001 | 001 | 35° | Orth. | *Serpierite* | Sul. | Y=*a*. X=gr., Y, Z=gr.-blue | 102 |
| X⊥001 cl.± | 001 | 0°± | Mon. | **BIOTITE** | Sil. | Y=*b*. Br. or gr.: X<Y, Z | 272 |
| X⊥001 cl.± | 001 | 0°± | Mon. | *Stilpnomelane* | Sil. | X=yel., Y, Z=brown | 435 |
| X⊥001 cl.± | 001 | 0°± | Mon. | *Ekmannite* | Sil. | Greenish: X<Y=Z | 281 |
| X⊥001 cl.± | 001 | 39° | Mon. | *Herrengrundite* | Sul. | Z=*b*. Green: X<Y, Z. G.=3.1 | 104 |
| 001 perf. | 001 | 80° | Mon. | *Epistolite* | Sil. | Y=*b*. Z∧*c*=7°. G.=2.9 | 442 |
| X⊥010 cl. | Fib. | 84° | Mon. | *Annabergite* | Arsen. | Z∧*c*=36°. Green± | 127 |
| X⊥010 cl. | Fib. | 90°± | Mon. | *Cabrerite* | Arsen. | Z∧*c*=33°. Green± | 127 |
| 100, 010 perf. | Prism. | 28°± | Tr. | *Amarantite* | Sul. | X⊥100±. Yel.: X<Y<Z | 109 |

**Group 54a.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 perf. | Prism. | 0° | Tet. | Xenotime | $YPO_4$ | Colorless or X = pink, Z = brown | 138 |
| 0001 perf. | Prism. | 0° | Hex. | *Parisite* | Carb. | Yel.: X<Z. G.=4.4 | 85 |
| 0001 part. | Prism. | 0° | Hex. | *Bastnäsite* | Carb. | Yellow. G.=5 | 85 |
| Z=*c* | Acic. | 0°± | ? | *Mixite* | Arsen. | Green. G.=3.8 | 156 |
| Z⊥001 cl. | Fib. | 28°± | Orth. | *Ferrimolybdite* | Molyb. | Y=*a*. Yel.: X, Y<Z. G.=4.5 | 108 |
| X⊥010 cl. | Dom. | 35° | Orth. | *Antlerite* | Sul. | Y=*c*. Green: Y>Z>X | 102 |
| X⊥cleav. | Fib. | Mod. | Orth. | *Planchéite* | Sil. | Z=*c*. Blue: X, Y<Z | 411 |
| X⊥010 cl. | Prism. | 75° | Orth. | *Astrophyllite* | Sil. | Z=*a*. Yellow: X>Y>Z | 417 |
| Z⊥001 cl. | ? | 84° | Orth. | *Curtisite* | C, H, O | Y=*b*. Yellow: X<Y<Z | 18 |
| Y⊥010 cl. | Fib. | 73° | Mon.? | *Lindackerite* | Sul. | X∧*c*=26°. Green | 121 |
| X⊥010 cl. | Fib. | 77° | Mon. | *Koettigite* | Arsen. | Z∧*c*=37°. Carmine | 127 |
| X⊥010 cl. | Prism. | 89° | Mon. | Erythrite | Arsen. | Z∧*c*=32°. X=pink, Y=violet, Z=red | 127 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### VII. BIREFRINGENCE EXTREME: $N_g - N_p > 0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 54b.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically — | | | |
| | | | | A. No visible cleavage | | | |
| $X=c$ | 0001 | 0° | Hex. | *Chloromagnesite* | Hal. | Sol. $H_2O$. Deliques. | 32 |
| 010, 110 | Acic. | 7° | Orth. | *Alstonite* | Carb. | $X=c$. $Y=b$. G.=3.7. Sol. HCl | 80 |
| 110 dist. | Acic. | 11° | Orth. | Strontianite | Carb. | $X=c$. $Y=b$. G.=3.7. Sol. HCl | 81 |
| 010 dist. | Pyr. | 16° | Orth. | Witherite | Carb. | $X=c$. $Y=b$. G.=4.3. Sol. HCl | 81 |
| 010, 110 | Acic. | 18° | Orth. | **Aragonite** | Carb. | $X=c$. $Y=a$. G.=2.94. Sol. HCl | 79 |
| $X=c$ | Fib. | Sm. | Orth. | *Sussexite* | Bor. | G.=3.12. Sol. HCl | 91 |
| $X=a$. $Y=b$ ? | Pyr. | 66° | Orth. | *Ancylite* | Carb. | Green. G.=3.95. Sol. HCl | 87 |
| $X \perp 010$ cl. | 010 | Lg. | Mon. | *Zippeite* | Sul. | $Z \wedge c = 35°\pm$. Yel.: $X<Y<Z$ | 110 |
| 010 dist. | 100 | Lg. | Tr. | *Stewartite* | Phos. | $X=a\pm$. Yel.: $X<Y<Z$. G.=2.9 | 128 |
| | | | | B. One visible cleavage | | | |
| $X \perp 001$ cl.± | 001 | 0°± | Mon. | **BIOTITE** | Sil. | $Y=b$. Br. or gr.: $X<Y, Z$ | 272 |
| $X \perp 001$ cl.± | 001 | 0°± | Mon. | *Ekmannite* | Sil. | Gr.-brown: $X<Y=Z$ | 281 |
| $Y \perp 100$ cl.± | 100 | Sm. | Mon. | *Aurichalcite* | Carb. | $Z \wedge c$=Sm. Green: $X<Y, Z$ | 84 |
| $X \perp 001$ cl.± | 001 | Sm. | Mon. | *Stilpnomelane* | Sil. | X=yel., Y, Z=gr. or br. | 435 |
| $X \perp 001$ cl.± | 001 | 35°± | Mon. | *Roscoelite* | Sil. | $Z=b$. X, Y=olive, Z=gr.-br. | 270 |
| 100 perf. | 100 | 40° | Mon. | *Hydrozincite* | Carb. | $X=b$. $Z \wedge c$=Mod. G.=3.6 | 83 |
| $X \perp 010$ cl. | Prism. | 87° | Mon. | *Symplesite* | Arsen. | $Z \wedge c = 32°$. Yel., gr., bl.; pleo. | 126 |
| | | | | C. Two or more visible cleavage directions | | | |
| $10\bar{1}1$ perf. | Var. | 0° | Rhom. | *Manganocalcite* | Carb. | G.=2.9±. Sol. HCl | 72 |
| $10\bar{1}1$ perf. | Var. | 0° | Rhom. | *Plumbocalcite* | Carb. | G.=2.72+. Sol. HCl | 72 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | **MG-DOLOMITE** | Carb. | G.=2.9+. Sol. HCl | 73 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | Mangandolomite | Carb. | G.=3.3±. Sol. HCl | 73 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | Ankerite | Carb. | G. = 3±. Sol. HCl | 73 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Breunnerite* | Carb. | G. = 3±. Sol. HCl | 75 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | Magnesite | Carb. | G. = 3±. Sol. HCl | 75 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Mesitite* | Carb. | G. = 3.2±. Sol. HCl | 75 |
| 110 perf. | Var. | 14° | Mon. | *Barytocalcite* | Carb. | $X \wedge c = 64°$. $Z = b$. G. = 3.6 | 82 |
| 110 at 56° | Prism. | 80°± | Mon. | **OXYHORNBLENDE** | Sil. | $Y = b$. $Z \wedge c = 5°±$. Br. or gr. $X < Y, Z$ | 252 |

**Group 55a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically +

A. No visible cleavage and not elongated or with negative elongation

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 dist. | 001 | 0° | Tet. | *Calomel* | $Hg_2Cl_2$ | Also pyr. G. = 6.5 | 30 |
| $Z = c$ | 0001 | 0° | Hex. | *Vegasite* | Sul. | Yellow: $X < Z$ | 116 |
| 100, 001 | Prism. | Sm. | Orth. | *Hoelite* | C, H, O | $X = c$. $Y = a$. G. = 1.4 | 18 |
| 110 dist. | Wedge | 30°± | Mon. | **Titanite** | Sil. | $Y = b$. $Z \wedge c = 51°$. Colorless or pleo. | 204 |
| 110 dist. | Wedge | 50°± | Mon. | *Keilhauite* | Sil. | $Y = b$. $Z \wedge c = 51°$. Brown; pleo. | 205 |
| 011 dist. | Prism. | 90°± | Mon. | *Lautarite* | Iod. | $X \wedge c = 25°$. $Y = b$. G. = 4.6 | 89 |

B. No visible cleavage and positive elongation

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $Z = c$ | Prism. | 0° | Tet. | **Zircon** | $ZrSiO_4$ | Colorless or tinted. G. = 4.7 | 183 |
| $Z \parallel 110$ cl. | Prism. | 0° | Tet. | Cassiterite | $SnO_2$ | Colorless or br., etc. G. = 7 | 52 |
| $Z = c$ | Prism. | Sm. | Orth. | *Ludwigite* | Bor. | X, Y = gr., Z = br. G. = 4 | 94 |
| $Z = c$ | Acic. | Sm. | Orth. | *Mixite* | Arsen. | Green. G. = 3.8 | 156 |
| $Z \perp 001$ cl. | Fib. | 28° | Orth. | *Ferrimolybdite* | Molyb. | $X = b$. Yel.: $X, Y < Z$. G. = 4.5 | 108 |
| $X \perp 010$ cl. | Prism. | 35° | Orth. | *Hemafibrite* | Arsen. | $Y = a$. Red-br. G. = 3.6 | 136 |
| $X \perp 100$ | 100 | Mod. | Orth. | *Uraconite* | Sul. | $Y = b$. Yellow. Sol. HCl | 110 |
| $X \perp 100$ | 100 | 82° | Orth. | *Olivenite* | Arsen. | $Y = c$. Olive: $X, Y < Z$. G. = 4 | 132 |
| $X \perp 010$ | 010 | 58° | Mon. | *Schultenite* | Arsen. | $Z \wedge c = +66°$. G. = 5.94 | 123 |
| $Z \wedge c$ = Sm. | Fib. | Lg. | Mon. | *Shattuckite* | Sil. | $X = b$. Blue: $X < Y < Z$. G. = 3.8 | 411 |
| $X \wedge c = 22°$ | El. $\parallel b$ | 90°± | Tr.? | *Dihydrite* | Phos. | $Z = b±$. X = bl., Y = gr., Z = br. | 135 |

C. One or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 perf. | Pyr. | 0° | Tet. | *Trippkeite* | Arsen. | Bl.-green. Sol. HCl | 159 |
| $X \perp 001$ cl. | ? | 38° | Orth. | *Purpurite* | Phos. | $Y = a$. X = gray; Y, Z = red | 141 |

# TABLE II.—BIREFRINGENCE OF MINERALS

## VII. Birefringence extreme: $N_g - N_p > 0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 55a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically +, *continued* | | | | | | | |
| C. One or more visible cleavage directions—*continued* | | | | | | | |
| Z ‖ fib. | Fib. | 40° | Orth. | *Taramellite* | Sil. | X, Y = red; Z = br. G. = 3.9 | 427 |
| Two pinac. | ? | 52° | Orth. | *Uvanite* | Van. | Brown: Y > X > Z | 148 |
| X ⊥ 100 cl. | Fib. | Lg. | Orth. | *Uranospherite* | Uran. | X = *b*. Yellow. G. = 6.36 | 109 |
| Y ⊥ 010 cl. | Prism. | 58° | Mon. | *Claudétite* | $As_2O_3$ | $Z \wedge c = 6°$. G. = 4 ± | 45 |
| 021 perf. | Var. | 68° | Mon. | Azurite | Carb. | X = *b*. $Z \wedge c = 12°$. Blue: X < Y < Z | 82 |
| 001 perf. | 001 | 70° ± | Mon. | *Piedmontite* | Sil. | $X \wedge c = 7°$. Y = *b*. X = yel., Z = red | 315 |
| Z ⊥ 010 cl. | Fib. | 90° | Mon.? | *Dufrenite* | Phos. | X = *c* ±. X = br., Y = yel., Z = gr. | 142 |
| **Group 55b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically − | | | | | | | |
| A. No visible cleavage and uniaxial | | | | | | | |
| X ⊥ 001 cl. | ? | 0° | Tet. ? | *Arseniosiderite* | Arsen. | X = yel., Z = brown. G. = 3.7 ± | 153 |
| X ⊥ 0001 cl. | Prism. | 0° | Hex. | *Cordylite* | Carb. | X = br., Z = gr.-yel. G. = 4.3 | 86 |
| X = *c* | Fib. | 0° | Hex. | *Ferritungstite* | Tung. | Yellow. Dec. HCl | 107 |
| 0001 dist. | 0001 | 0° | Rhom. | *Carphosiderite* | Sul. | Yellow. G. = 2.6 ± | 108 |
| 0001 dist. | 0001 | 0° | Rhom. | *Jarosite* | Sul. | Yellow: X < Z. G. = 3.2 | 114 |
| 0001 dist. | 0001 | 0° | Rhom. | *Natrojarosite* | Sul. | Yellow: X < Z. G. = 3.2 | 114 |
| $10\bar{1}1$ dist. | 0001 | 0° | Rhom. | *Plumbojarosite* | Sul. | X = golden, Z = red. G. = 3.6 | 115 |
| X = *c* | Prism. | 0° ± | ? | *Mazapilite* | Arsen. | Brown: X < Z. G. = 3.6 | 156 |
| B. No visible cleavage and biaxial | | | | | | | |
| Z ‖ elong. | Lath | ? | Orth. | *Chapmanite* | Sil. | Olive green. G. = 3.6 | 440 |
| X = *a*. Y = *c* | Dom. | 33° | Orth. | *Cornetite* | Phos. | Green. G. = 4.1. Sol. HCl | 132 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X=*b*. Y=*c* | Eq. | 83° | Orth. | *Libethenite* | Phos. | Green. X, Z<Y. G.=3.7 | 132 |
| 010 cleav. | Fib. | Sm. | Mon. | *Tagilite* | Phos. | X∧elong.=Sm. Green | 137 |
| Z ‖ elong. | Fib. | 50° | Mon. | *Pseudomalachite* | Phos. | Green. G.=3.6 | 135 |
| X⊥010 cl.± | 010 | 24° | Tr. | *Chalcosiderite* | Phos. | Green: X<Z. G.=3.1 | 157 |
| X⊥010± | 010 | 52° | Tr. | *Walpurgite* | Arsen. | Yellow. G.=5.8 | 148 |

C. One or two visible cleavage directions and uniaxial or 2V<40°

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X⊥001 cl. | 001 | 0° | Tet.? | *Freirinite* | Arsen. | Gr.-blue: X<Z. Sol. HCl | 151 |
| X⊥001 cl. | Prism. | 22° | Orth. | *Durdenite* | Tel. | Y=*b*. Yel.: X<Y<Z | 118 |
| Z⊥cleav. | ? | Mod. | Orth. | *Erinite* | Arsen. | Y ‖ elong. Green. G.=4 | 133 |
| X⊥001 cl. | 001 | 40° | Orth. | *Carnotite* | Van. | Y=*a*. Yellow± | 148 |
| X⊥001 cl.± | 001 | 0°± | Mon. | *Chalcodite* | Sil. | X=yel.; Y, Z=red-br. G.=3± | 435 |
| Z ‖ elong. | Lam. | Sm. | Mon.? | *Aurichalcite* | Carb. | Y=*a*±. Green. X<Y, Z | 84 |
| 001 perf. | 001 | 10° | Mon. | *Leadhillite* | Sul. | X∧*c*=5°. Z=*b*. G.=6.4 | 120 |

D. One or two visible cleavage directions and 2V>40°

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X⊥001 cl. | 001 | 40° | Orth. | *Carnotite* | Van. | Y=*a*. Yellow± | 148 |
| X⊥001 cl. | 001 | 45°± | Orth. | *Tyuyamunite* | Van. | Y=*b*. Yellow: X<Y<Z | 147 |
| X⊥010 cl. | Prism. | 72° | Orth. | *Brochantite* | Sul. | Y=*a*. Green: X, Y<Z | 102 |
| X⊥001 cl. | El. ‖ *a* | 81° | Orth. | *Langite* | Sul. | Y⊥010 cl. Green; pleo. | 102 |
| Z⊥001 cl. | El. ‖ *a* | 85° | Orth. | *Caledonite* | Sul. | X⊥100 cl. Bl.-green; pleo. | 120 |
| 001, 010 | Fib. | 43° | Mon. | Malachite | Carb. | X∧*c*=24°. Y=*b*. Green: X<Y<Z | 83 |
| X⊥001 cl.± | El. ‖ *b* | 47° | Mon. | *Lanarkite* | Sul. | Y=*b*. G.=6.6 | 102 |
| X⊥001 cl.± | Prism. | 53° | Mon. | *Clinoclasite* | Arsen. | Y=*b*. Green; Pleo. G.=4.3 | 135 |
| 110 at 87° | Prism. | 60°± | Mon. | **Acmite** | Sil. | X∧*c*=5°. Y=*b*. G.=3.5. Gr. or br.; pleo. Sol. HF | 234 |

E. Three visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | Ankerite | Carb. | G.=3.0. Sol. HCl | 73 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Ferrodolomite* | Carb. | G.=3.3. Sol. HCl | 73 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Mangandolomite* | Carb. | G.=3.3. Sol. HCl | 73 |

## TABLE II.—BIREFRINGENCE OF MINERALS

### VII. Birefringence extreme: $N_g - N_p > 0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 55b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically −, *continued* | | | |
| | | | | E. Three visible cleavage directions—*continued* | | | |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Mesitite* | Carb. | G.=3.2. Sol. HCl | 75 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Pistomesite* | Carb. | G.=3.5. Sol. HCl | 75 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Sideroplesite* | Carb. | G.=3.8. Sol. HCl | 75 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | **Siderite** | Carb. | Gray. G.=3.9. Sol. HCl | 76 |
| $01\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Oligonite* | Carb. | G.=3.8. Sol. HCl | 76 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | Rhodochrosite | Carb. | G.=3.7. Sol. HCl | 77 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | *Spherocobaltite* | Carb. | G.=4.1. Sol. HCl | 78 |
| $10\bar{1}1$ perf. | Rhom. | 0° | Rhom. | Smithsonite | Carb. | G.=4.3. Sol. HCl | 78 |
| 010 + two | Lam. | 83° | Tr. | *Margarosanite* | Sil. | $X' \wedge$ cleav. in 010=44°. G.=4.0 | 406 |
| | | | | **Group 56a.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically + | | | |
| | | | | A. No visible cleavage and no elongation | | | |
| $Z=c$ | Pyr. | 0° | Tet. | *Tapiolite* | Tant. | X=br., Z=opaque | 164 |
| $Z=a$ | Var. | Sm. | Orth. | *Brookite* | $TiO_2$ | Yel.: X<Y<Z. Ext. Disp. | 59 |
| ? | ? | Sm. | ? | *Tripuhyite* | Antim. | Gr.-yel. G.=5.8 | 160 |
| ? | ? | Sm. | Orth. | *Hjelmite* | Tant. | X, Y=yel.-br.; Z=opaque | 166 |
| $Y=b$. $Z=c$ | Pyr. | 69° | Orth. | Sulfur | S | G.=2. Sol. $CS_2$ | 14 |
| | | | | B. No visible cleavage and prismatic or lamellar elongation | | | |
| 110 dist. | Prism. | 0° | Tet. | **Rutile** | $TiO_2$ | Br.-red: X<Z. G.=4.3± | 50 |
| 0001 dist. | Prism. | 0° | Hex. | *Penfieldite* | Hal. | Sol. $HNO_3$. F=1 | 38 |
| ? | Prism. | Sm. | Orth. | *Derbylite* | Tit. | Brown. G.=4.5 | 162 |
| Two cleav. | Prism. | 67° | Orth. | *Melanotekite* | Sil. | Brown: X<Y<Z. G.=5.7 | 427 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 dist. | Prism. | 88° | Orth. | *Kentrolite* | Sil. | Red-brown: X<Y<Z. G.=6.2 | 427 |
| 100 dist. | Prism. | Lg. | Orth. | *Tantalite* | Tant. | Red to opaque. G.=7.5± | 165 |
| 110 at 86° | Prism. | 57° | Mon. | *Crocoite* | Chrom. | Y=*b*. Z∧*c*=6°. Yellow | 101 |
| ? | Prism. | Lg. | Mon.? | *Brackebuschite* | Van. | Brown: X<Y, Z | 125 |
| One cleav. | Lam. | 83° | Mon. | *Calciovolborthite* | Van. | Green. Ext. Disp. | 135 |
| | | | C. One or more visible cleavage directions and lamellar elongation | | | | |
| 10$\bar{1}$0 perf. | 0001 | 0° | Hex. | Cinnabar | HgS | Red. G.=8.2 | 21 |
| One perf. | Tab. | Mod. | Orth. | *Phenicochroite* | Chrom. | Red. G.=5.75. Sol. HCl | 100 |
| 001 perf. | 010 | 67° | Orth. | *Cotunnite* | $PbCl_2$ | Y=*b*. Z=*c*. G.=5.8 | 32 |
| 010, 001 | 010 | 83° | Orth. | *Lepidocrocite* | Ox. | Orange: X<Y<Z. G.=4.1 | 48 |
| 100 perf. | 100 | Lg. | Orth. | *Nadorite* | Antim. | Yellow. X=*a*. Y=*b*. G.=7 | 159 |
| 100 perf. | 100 | Lg. | Orth. | *Massicotite* | PbO | Yel.: X, Y<Z. G.=9.3 | 41 |
| 010 perf. | 010 | 90°± | Orth. | *Tellurite* | $TeO_2$ | X=*b*. Y=*a*. G.=5.9 | 59 |
| X⊥010 cl. | 010 | 24° | Mon. | Orpiment | $As_2S_3$ | Z=*a*±. Yellow. G.=3.4 | 25 |
| | | | D. One or more visible cleavage directions and prismatic elongation | | | | |
| 010, 110 | Prism. | Sm. | ? | *Manganite* | Ox. | Y=*b*. Z=*c*. Brown: X<Z | 48 |
| X⊥100 cl. | Prism. | 75°± | Orth. | *Stibiotantalite* | Tant. | Z=*c*. Brown±. G.=7.9 | 167 |
| 110, 100, 010 | Fib. | Lg. | Orth. | *Mendipite* | Hal. | X=*a*. Z=*c*. G.=7 | 38 |
| 010 perf. | Prism. | Lg. | Orth. | *Montroydite* | HgO | Z=*c*. Yellow. Sol. HCl | 41 |
| 100, 001 | Prism. | ? | Mon. | *Lorandite* | $TlAsS_2$ | Red. G.=4.5. Sol. $HNO_3$ | 28 |
| 100, 101 | Dom. | Sm. | Mon.? | *Kermesite* | $Sb_2S_2O$ | Y or Z=*b*. Red: X>Y>Z | 28 |
| X⊥010 cl. | Prism. | 73° | Mon. | Huebnerite | Tung. | Z∧*c*=18°. Br., gr.; pleo. | 101 |
| | | | **56b.** Refringence positive and extreme: $N_o$ or $N_m>2.00$. Optically − | | | | |
| | | | A. No visible cleavage and uniaxial and not red | | | | |
| 101 dist. | ? | 0° | Tet. | *Cumengéite* | Hal. | Blue. G.=4.8± | 37 |
| X=*c* | Pyr. | 0° | Tet. | *Stolzite* | Tung. | G.=8±. Dec. $HNO_3$ | 98 |
| X=*c* | Prism. | 0° | Tet. | *Plattnerite* | $PbO_2$ | Brown. Also biax. G.=8.5 | 53 |
| 001 dist. | Pyr. | 0° | Tet. | *Ecdemite* | Arsen. | Green. Also biax. G.=7± | 159 |
| 111 dist. | 001 | 0° | Tet. | Wulfenite | Molyb. | Colorless or yellow: X<Z. G.=6.9 | 98 |

TABLE II.—BIREFRINGENCE OF MINERALS

VII. BIREFRINGENCE EXTREME: $N_g - N_p > 0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | **Group 56b.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically −, *continued* | | | | | |
| | | A. No visible cleavage and uniaxial and not red—*continued* | | | | | |
| 001 dist. | Pyr. | 0° | Tet. | *Hausmannite* | Ox. | Brown to opaque. G.=4.8 | 64 |
| 001, 111 | Pyr. | 0° | Tet. | *Anatase* | $TiO_2$ | Yel., bl.: X<Z. G.=3.8± | 53 |
| X=*c* | ? | 0° | ? | *Bindheimite* | Antim. | Gray, etc. G.=4.8± | 160 |
| X=*c* | Fib. | 0° | Hex.? | *Bismutospherite* | Carb. | Yellow, etc. G.=7.4± | 86 |
| X=*c* | Prism. | 0° | Hex. | Vanadinite | Van. | Colorless or yel. X<Z | 131 |
| | | B. No visible cleavage and uniaxial and red | | | | | |
| X=*c* | Rhom. | 0° | Rhom. | **HEMATITE** | $Fe_2O_3$ | Red to black. G.=5.2 | 44 |
| X=*c* | Fib. | 0° | ? | *Hydrohematite* | Ox. | Red. G.=4.5-5. Sol. HCl | 45 |
| $10\bar{1}1$, 0001 | Prism. | 0° | Rhom. | *Trechmannite* | $AgAsS_2$ | X=colorless, Z=red. Inverts | 27 |
| $10\bar{1}1$ dist. | Prism. | 0° | Rhom. | Pyrargyrite | $Ag_3SbS_3$ | Red. G.=5.8 | 27 |
| $10\bar{1}1$ dist. | Rhom. | 0° | Rhom. | *Proustite* | $Ag_3AsS_3$ | Red. G.=5.6 | 27 |
| | | C. No visible cleavage and biaxial with parallel extinction in axial zones | | | | | |
| 110 at 90°± | Prism. | ? | ? | *Livingstonite* | $HgSb_4S_7$ | Z=*c*. Red: X>Z. G.=4.8 | 28 |
| 110, 021 | 010 | 9° | Orth. | Cerussite | Carb. | X=*c*. Y=*b*. G.=6.57 | 80 |
| X⊥010 cl. | 010 | 32° | Orth. | *Pinakiolite* | Bor. | Y=*c*. Red-br.: Y>X>Z | 94 |
| Y⊥100 cl. | Prism. | 38° | Orth. | *Hutchinsonite* | Tl, As, S | X=*b*. Scarlet. G.=4.6 | 28 |
| Z ∥ elong. | Lath | Mod. | Orth. | *Hewettite* | Van. | X, Y=yel.; Z=red. G.=2.55 | 160 |
| Z ∥ elong. | Lath | 52° | ? | *Metahewettite* | Van. | X=yel.; Y, Z=red. G.=2.55 | 160 |
| X ∥ elong. | Fib. | 60° | Orth. | *Cuprodescloizite* | Van. | X=colorless; Y, Z=red-br. | 133 |
| X=*c*. Y=*b* | Pyr. | Lg. | Orth. | *Descloizite* | Van. | X=yel., Y=gr.-yel., Z=golden | 133 |
| X⊥100 cl. | Prism. | 82° | Orth. | *Laurionite* | Hal. | Y=*b*. Colorless to gray. G.=6.2 | 38 |
| | | D. No visible cleavage and biaxial with inclined extinction in axial zones | | | | | |
| 001, 100 | 100 | ? | Mon. | *Fiedlerite* | Hal. | Z=*b*. G.=5.9. Sol. $HNO_3$ | 39 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 001 dist. | Ps. Tet. | Sm. | Mon.? | *Schwartzembergite* | Hal. | $X = c\pm$. Yel. G. = 7.4 | 38 |
| X ‖ elong. ± | Fib. | Sm. | Mon. | *Vauquelinite* | Chrom. | Colorless or X = gr., Y, Z = br. | 121 |
| $X = c\pm$. $Z = b$ | 001 | 20° ± | Mon. | *Polybasite* | Ag, Sb, S | Red. G. = 6.1. Dec. $HNO_3$ | 27 |
| Y ⊥ 010 cl. | Prism. | 40° | Mon. | Realgar | AsS | $X \wedge c = 11°$. Orange; pleo. | 22 |
| 001 dist. | 100 | ? | Mon. | *Paralaurionite* | Hal. | $Y = b$. Colorless or violet | 39 |
| 111, 11$\bar{1}$, 001 | Lath | ? | Tr. | *Tenorite* | CuO | X = br., Z = opaque. G. = 6.4 | 41 |
| **E. One or more visible cleavage directions and uniaxial** | | | | | | | |
| 110 perf. | 001 | 0° | Tet. | *Lithargite* | PbO | Yel.-red. G. = 9.1 | 41 |
| 001 perf. | 001 | 0° | Tet. | *Matlockite* | Hal. | Yel. or gr. G. = 7.2 | 37 |
| 001 perf. | 001? | 0° | Tet. | *Heterolite* | Ox. | Brown: X > Z. G. = 4.8 ± | 65 |
| 0001 perf. | 0001 | 0° | Hex. | *Hydrocerussite* | Carb. | G. = 6.8. Sol. $HNO_3$ | 82 |
| 0001 perf. | 0001 | 0° | Hex. | *Bismite* | Ox. | G. = 4.36. Sol. $HNO_3$ | 43 |
| 0001 perf. | Rhom. | 0° | Rhom. | *Chalcophanite* | Ox. | X = red, Z = opaque. G. = 3.9 | 66 |
| 10$\bar{1}$1 perf. | ? | 0° | Rhom. | *Geikielite* | $MgTiO_3$ | Purple. G. = 3.9. Sol. HCl | 67 |
| 02$\bar{2}$1, 10$\bar{1}$2 | 0001 | 0° | Rhom. | *Pyrophanite* | $MnTiO_3$ | Yel.-red. G. = 4.5. Sol. HCl | 67 |
| **F. One or more visible cleavage directions and biaxial with parallel extinction in axial zones** | | | | | | | |
| X ⊥ 010 cl. | Prism. | Sm. | Orth. | **Goethite** | Ox. | Yellow; pleo. G. = 4.2 | 47 |
| 010 perf. | Prism. | Sm. | Orth. | *Valentinite* | $Sb_2O_3$ | $X = a$. Extr. Disp. G. = 5.76 | 45 |
| X ⊥ 001 cl. | 001 | Sm. | Orth. | *Tungstite* | Ox. | Yellow: X > Y > Z. G. = 5.5 | 60 |
| X ⊥ 001 cl. | 001 | 19° | Orth. | *Pucherite* | Van. | $Z = b$. Red-br. G. = 6.25 | 138 |
| Z ⊥ 010 cl. | Prism. | 26° | Orth. | Stibnite | $Sb_2S_3$ | $X = c$. Red to opaque. G. = 4.6 | 25 |
| Z ⊥ 100 cl. | 100 | Lg. | Orth. | *Koechlinite* | Molyb. | $Y = c$. Yellow. Sol. HCl | 107 |
| **G. One or more visible cleavage directions and biaxial with inclined extinction in axial zones.** | | | | | | | |
| 001 perf. | 001 | 10° | Mon. | ***Leadhillite*** | Sul. | $X \wedge c = 6°$. $Z = b$. G. = 6.3 ± | 120 |
| Y ⊥ 010 cl. | Fib. | 20° | Mon. | ***Emmonsite*** | Tel. | X ⊥ 001? cl. ± | 118 |
| 101 perf. | El. ‖ *b* | 20° | Mon. | ***Terlinguaite*** | Hal. | $Y \wedge c = 7°$. Yellow. G. = 8.7 | 39 |
| 001 perf. | 100 | 30° | Mon. | ***Baddeleyite*** | $ZrO_2$ | $X \wedge c = 12°$. $Y = b$. Gr., br. X > Z | 60 |
| 100 perf. | 001 | 65° | Mon. | ***Smithite*** | $AgAsS_2$ | $Y = b$. $Z \wedge c = 7°$. Scarlet | 27 |
| 001, 100 | El. ‖ *b* | Lg. | Mon. | ***Chloroxiphite*** | Hal. | $X = c\pm$. $Z = b$. Y = br., Z = gr. | 39 |

## SUPPLEMENTARY TABLE II.—BIREFRINGENCE OF MINERALS

### O. Birefringence zero: $N_g - N_p = 0.000$

| Cleavage, Optic Orient. | Habit, etc. | Color | N | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 1.** Refringence negative and distinct: $N < 1.48$ | | | |
| | | | | A. Uncolored in thin section and not isometric | | | |
| None | Liquid | Colorless | 1.333 | *Water* | Ox. | G. = 1.0 | 40 |
| | | | | B. Uncolored in thin section and isometric | | | |
| 111 perf. | Oct. | Colorless | 1.369 | *Cryptohalite* | Hal. | G. = 2.00; sol. hot $H_2O$ | 36 |

### I. Birefringence very weak: $N_g - N_p < 0.0035$

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 12.** Refringence positive and high: $N_o$ or $N_m > 1.74 < 2.00$. Optically + or − | | | |
| $Z=c$ | ? | 0° | Tet. | *Cahnite* | Arsen. | Abn. int. colors | 161 |
| $Z=c$ | ? | 0° | Hex. | *Abukumalite* | Sil. | G. = 4.35 | * |

### II. Birefringence weak: $N_g - N_p > 0.0035 < 0.0095$

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 15a.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically +. | | | |
| | | | | A. No visible cleavage | | | |
| $Z=c$ | Rhom. | 0° | Rhom. | *Schairerite* | Sul. | G. = 2.61. Sol. $H_2O$ | 119 |
| $X=c$ | 010 | 11° | Orth. | *Feruccite* | $NaBF_4$ | G. = 2.50. Sol. $H_2O$ | ** |
| $Y=b$ | 100 | 79° | Mon. | *Jarlite* | Hal. | $X \wedge \perp 100 = 16°$ | *** |
| | | | | B. One or more visible cleavages | | | |
| $Z \wedge cl. = 33°$ | ? | 83° | Mon.? | *Bakerite* | Hal. | G. = 2.96 | *4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | **Group 16a.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically + | | | |
| | | | | B. One or more visible cleavages | | | |
| $X = c$ | Prism. | Lg. | Orth. | *Minyulite* | Phos. | G. = 2.45 | *5 |
| ? | ? | Lg. | Orth. | *Ashtonite* | Sil. | Cleav. angles of 83° and 90° | 432 |
| 100, 001 | Prism. | 65° | Mon. | *Dachiardite* | Sil. | $X = b$. $Z \wedge c = -35°$ | 399 |
| | | | | **Group 17a.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically + | | | |
| | | | | B. One or more visible cleavages | | | |
| $Z \perp 001$ cl. | Pyr. | 0° | Tet.? | *Wardite* | Phos. | G. = 2.81 | 158 |
| 100, 001 | Prism. | 0° | Tet. | *Ashcroftine* | Sil. | G. = 2.61 | *6 |
| | | | | **Group 17b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically − | | | |
| | | | | B. One visible cleavage | | | |
| 001 perf. | 001 | 70° | Mon. | *Dickite* | Sil. | $Y \wedge a = 11°$ | 264 |
| | | | | **Group 18a.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically + | | | |
| | | | | A. No visible cleavage | | | |
| ? | ? | 0° | Rhom. | *Deltaite* | Phos. | G. = 2.95 | 155 |
| Z ‖ elong. | Fib. | 0°± | Orth.? | *Garnierite* | Sil. | Bluish green with X<Z | *7 |
| | | | | B. One or more visible cleavages | | | |
| 0001 perf. | Fib. | 0° | Hex. | *Pseudowavellite* | Phos. | X ‖ fibers. G. = 2.92 | 155 |
| | | | | **Group 18b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically − | | | |
| | | | | A. No visible cleavage and no marked elongation | | | |
| $X = c$ | Prism. | 0° | Hex. | *Ellestadite* | Sil. | G. = 3.07 | *8 |

* S. Hata: *Sci. Pap. Inst. Phys. Chem. Res. Tokyo*, XXXIV, 1938, p. 1018.
** G. Carobbi: *Mineral. Abst.*, V, 1933, p. 390.
*** R. Bøgvad: *Med. Grönland*, XCII, 1933, No. 8.
*4 R. Bøgvad: *Med. Grönland*, CXIX, 1938, No. 7.
*5 E. S. Simpson and C. R. Le Mesurier: *Jour. Roy. Soc. W. Australia*, XIX, 1932, p. 13.
*6 M. H. Hey and F. A. Bannister: *Mineral. Mag.*, XXIII, 1933, p. 305.
*7 K. Spangenberg: *Zent. Mineral.*, 1938, A, p. 360.
*8 D. McConnell: *Am. Mineral.*, XXII, 1937, p. 977.

## SUPPLEMENTARY TABLE II.—BIREFRINGENCE OF MINERALS

### II. BIREFRINGENCE WEAK: $N_g - N_p > 0.0035 < 0.0095$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 18b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically −, *continued* | | | |
| | | | | A. No visible cleavage and no marked elongation—*continued* | | | |
| Z ‖ fib. | Prism. | 50°? | Orth. | *Juanite* | Sil. | H. = 5.5 Decomp. by acid | * |
| 001, 100, 010 | Prism. | 65° | Orth. | *Tuhualite* | Sil. | X = *a*, Y = *b*; X = pink, Y = purple, Z = violet | ** |
| | | | | C. One or more visible cleavages | | | |
| 0001 perf. | Prism. | 0° | Hex. | *Dehrnite* | Phos. | G. = 3.04 | 151 |
| | | | | **Group 19a.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically + | | | |
| | | | | B. One or more visible cleavages | | | |
| 001, 100 | Col. | 50° | Orth. | *Tawmawite* | Sil. | X = olive green, Y = brown, Z = emerald green | 317 |
| | | | | **Group 20b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically − | | | |
| ? | ? | 5° | Orth. | *Calcium-larsenite* | Sil. | G. = 4.42 | 187 |
| ? | ? | Biax. | ? | *Lessingite* | Sil. | G. = 4.69 | 422 |
| | | | | **Group 21.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically + or − | | | |
| X = *c*, Y = *a* | Ps. Hex. | Sm. | Orth. | *Britholite* | Sil. | Twins on 110 | 441 |
| | | | | III. BIREFRINGENCE MODERATE: $N_g - N_p > 0.0095 < 0.0185$ | | | |
| | | | | **Group 22a.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically + | | | |
| | | | | A. No visible cleavage | | | |
| ? | Powder | 0° | Rhom. | *Tincalconite* | Bor. | G. = 1.88 | 90 |
| | | | | **Group 24a.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically + | | | |
| | | | | C. One visible cleavage | | | |
| Z⊥0001 cl. | Lam. | 0° | Rhom. | *Manganbrucite* | Ox. | Sol. HCl | 42 |
| | | | | D. Two or more visible cleavage directions | | | |
| 100, 010 | Prism. | 70° | Tr. | *Bultfonteinite* | Sil. | $Z' \wedge c$ on 010 = 28°, G. = 2.73 | *** |

**Group 24b.** Refringence positive and low: $N_o$ or $N_m>1.53<1.59$. Optically –

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X=c$ | ? | 0°± | Tet. | *Aminoffite* | Sil. | G. = 2.94 | *4 |
| 010 perf. | 010 | 50° | Mon. | *Mooreite* | Sul. | $X=b$, $Z\wedge c=44°$ | 106 |
| $X\wedge b=4°\pm$ | Ps. Orth. | 60°± | Tr. | *Leightonite* | Sul. | Blue. $Y\wedge c=3°$ | *5 |

B. One or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X\perp$001 cl. | 001 | 61° | Orth. | *Saléite* | Phos. | G. = 3.1 | *6 |

**Group 25a.** Refringence positive and moderate: $N_o$ or $N_m>1.59<1.66$. Optically +

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 010 perf. | 001 | ? | Orth. | *Boehmite* | Ox. | Optic sign +? | 46 |
| $X=a$ | 010 | 15° | Orth. | *Roweite* | Bor. | G. = 2.92 | *7 |

C. Two or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 | ? | Var. | Orth.? | *Hydrophilite* | Hal. | Lamellar twinning | 32 |
| 100, $\bar{1}$02, 001 | Colum. | 44° | Mon. | *Parawollastonite* | Sil. | G. = 2.91 | *8 |
| 100, 010 | Prism. | 70° | Tr. | *Bultfonteinite* | Sil. | $Z'\wedge c$ on 010 = 28° | *9 |

**Group 25b.** Refringence positive and moderate: $N_o$ or $N_m>1.59<1.66$. Optically –

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X ‖ elong. | Fib. | Mod. | Orth.? | *Millisite* | Phos. | G. = 2.83 | 158 |

B. One visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0001 Perf. | ? | 0° | Hex.? | *Dennisonite* | Phos. | G. = 2.85 | 155 |
| 0001 Perf. | Prism. | Sm. | Hex.? | *Dehrnite* | Phos. | G. = 3.04 | 151 |

C. Two or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X\perp$0001 cl. | ? | 0°± | Hex. | *Lewistonite* | Phos. | G. = 3.06 | 151 |

* E. S. Larsen and E. A. Goranson: *Am. Mineral.*, XVII, 1932, p. 343.
** P. Marshall: *Trans. Roy. Soc. New Zealand*, LXV, 1936, p. 330.
*** J. Parry, A. F. Williams and F. E. Wright: *Mineral. Mag.*, XXIII, 1932, p. 145.
*4 C. S. Hurlbut: *Geol. För. Förh. Stockholm*, LIX, 1937, p. 290.
*5 C. Palache: *Am. Mineral.*, XXIII, 1938, p. 34.
*6 J. Thoreau and J. F. Vaes: *Bull. Soc. Belg. Geol.*, XLII, 1932, p. 96.
*7 H. Berman and F. A. Gonyer: *Am. Mineral.*, XXII, 1937, p. 301.
*8 M. A. Peacock: *Am. Jour. Sci.*, XXX, 1935, p. 495.
*9 J. Parry, A. F. Williams and F. E. Wright: *Mineral. Mag.*, XXIII, 1932, p. 145.

## SUPPLEMENTARY TABLE II.—BIREFRINGENCE OF MINERALS

### III. Birefringence moderate: $N_g - N_p > 0.0095 < 0.0185$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 26a.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically + | | | |
| | | | | B. No visible cleavage and inclined extinction in the chief zones | | | |
| ? | ? | Mod. | Mon. | *Acrochordite* | Arsen. | $X = b$, $Y \wedge c = 40°–45°$ | 137 |
| | | | | C. One visible cleavage | | | |
| 0001 perf. | Plates | 0°–20° | Rhom. | *Woodhouseite* | Sul. | G. = 3.01. Sol. HCl | * |
| | | | | D. Two or more visible cleavage directions | | | |
| $10\bar{1}0$ | Prism. | 0° | Hex. | *Bromellite* | Ox. | G. = 3.02 | ** |
| 110 | Lam. | Mod. | Orth.? | *Hydrophilite* | Hal. | Lamellar twinning | 32 |
| | | | | **Group 26b.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically − | | | |
| | | | | A. No visible cleavage and uniaxial | | | |
| X⊥001 cl. | Prism. | 0° | Tet. | *Iron-akermanite* | Sil. | G. = 3.23 | 209 |
| | | | | B. No visible cleavage and biaxial | | | |
| X ‖ needles | Prism. | Mod. | Orth. | *Gageite* | Sil. | G. = 3.58 | *** |
| | | | | C. One or more visible cleavage directions | | | |
| 001, 010 | ? | Lg. | Orth. | *Landesite* | Phos. | $X = c$, $Y = a$; X = dark brown, Y = light brown, Z = yellow | 151 |
| 110 perf. | Prism. | Lg. | Mono. | *Ferrotremolite* | Sil. | $Y = b$, $Z \wedge c = 10°$ | 247 |
| | | | | **Group 27a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically + | | | |
| | | | | A. No visible cleavage | | | |
| $X = c$ | Prism. | 0° | Hex. | *Hedyphane* | Phos. | Bluish in mass | 132 |
| $X \wedge c = 45°$ | Prism. | 37° | Mon. | *Synadelphite* | Arsen. | $Z = b$. G. = 3.57 | 155 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B. One or more visible cleavage directions | | | | | | | |
| 001, 010, 100 | ? | Mod. | Orth. | *Alluaudite* | Phos. | Z⊥best cl. | *4 |
| 001, 010 | Prism. | 70° | Orth. | *Varulite* | Phos. | Y = *b*. Optic sign +? | *5 |
| ? | ? | 68° | Mon. | *Repossite* | Phos. | G. = 3.74. | *6 |
| **Group 27b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically − | | | | | | | |
| ? | ? | 5° | Orth. | *Calcium-larsenite* | Sil. | G. = 4.42 | 187 |
| X∧*c* = 32° | ? | ? | Mon. | *Nagatelite* | Sil. | Y = *b*; X = brownish yellow, Y = reddish brown, Z = pale yellow | 317 |
| IV. Birefringence rather strong: $N_g - N_p > 0.0185 < 0.0275$ | | | | | | | |
| **Group 29a.** Refringence negative and distinct: $N_o$ or $N_m < 1.48$. Optically + | | | | | | | |
| ? | Var. | 80° | Mon. | *Lapparentite* | Sul. | G. = 1.89 | *7 |
| **Group 30b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically − | | | | | | | |
| A. No visible cleavage | | | | | | | |
| 001 poor | ? | 52° | Mon. | *Letovicite* | Sul. | X∧*c* = 17°, Z = *b*. G. = 1.81 | 97 |
| **Group 31b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically − | | | | | | | |
| B. One visible cleavage and parallel extinction | | | | | | | |
| X⊥001 cl. | 001? | 15° | Orth. | *Foshallasite* | Sil. | G. = 2.5 | *8 |
| X⊥cl. | Platy | Sm. | Orth. | *Truscottite* | Sil. | Silky luster | 409 |
| X⊥001 cl. ± | Lam. | Var. | Mon.? | *Skolite* | Sil. | Slowly sol. in acid | *9 |
| C. One visible cleavage and inclined extinction | | | | | | | |
| X⊥001 cl. ± | 001 | 24° | Mon. | *Hydrocalumite* | Ox. | Y = *b*. G. = 2.15 | *10 |

* D. M. Lemmon: *Am. Mineral.*, XXII, 1937, p. 939.

** G. Aminoff: Zeit. Krist., LXII, 1925, p. 113.

*** C. Palache: *U. S. Geol. Surv. Prof. P.* 180, 1935, p. 111.

*4 P. Quensel: *Geol. För. Förh. Stockholm*, LIX, 1937, p. 77.

*5 P. Quensel: *Geol. För. Förh. Stockholm*, LIX, 1937, p. 93. Optic sign from personal communication, Nov. 16, 1938.

*6 E. Grill: *Am. Mineral.*, XX, 1935, p. 740.

*7 R. Rost: *Mineral. Abst.*, VII, 1938, p. 11; M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 740.

*8 P. Tschirwinsky: *Mineral Abst.*, VII, 1938, p. 10.

*9 K. Smulikowski: *Am. Mineral.*, XXIII, 1938, p. 541.

*10 C. E. Tilley: *Mineral. Mag.*, XXIII, 1934, p. 607.

## SUPPLEMENTARY TABLE II.—BIREFRINGENCE OF MINERALS

IV. BIREFRINGENCE RATHER STRONG: $N_g - N_p > 0.0185 < 0.0275$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | **Group 32a.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically + | | | | |
| | | | B. One visible cleavage | | | | |
| 001 perf. | Lam. | 74° | Mon. | *Scawtite* | Sil. | $Y = b$; $Z \wedge a = 20°$ | 442 |
| | | | C. Two or more visible cleavage directions | | | | |
| Four cl. | Platy | 80° | Tr. | *Collinsite* | Phos. | G. = 2.95. Sol. in acid | 128 |
| X⊥001 cl. | Lam. | 0° ± | Mon. | *Schuchardtite* | Sil. | X = *blue-green*, Z = olive | * |
| | | | **Group 32b.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically − | | | | |
| | | | A. No visible cleavage | | | | |
| $X = c$ | Prism. | 0° | Tet. | *Mitscherlichite* | Hal. | Greenish blue | 34 |
| | | | B. One visible cleavage and uncolored | | | | |
| 001, 010 | ? | 66° ± | Tr. | *Sanbornite* | Sil. | Multiple twinning. G. = 4.19 | 407 |
| | | | **Group 33a.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically + | | | | |
| | | | A. No visible cleavage | | | | |
| ? | ? | 0° ± | Orth. | *Erikite* | Phos. | G. = 3.78 | ** |
| | | | B. One or more visible cleavage directions and parallel extinction in chief zones | | | | |
| 100 dist. | 010 | Mod. | Mon. | *Larnite* | Sil. | $X \wedge c = 13°–14°$; $Z = b$. | 194 |
| | | | **Group 33b.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically − | | | | |
| | | | A. No visible cleavage | | | | |
| $Z = c$ | Prism. | 40° | Orth. | *Seamanite* | Phos. | $Y = b$. G. = 3.13 | 161 |
| ? | Gran. | 70° ± | ? | *Metahohmanite* | Sul. | X = *yellow*, Y = red yellow, Z = brown | *** |
| | | | B. One visible cleavage | | | | |
| X⊥100 cl. | 100 | 70° | Orth. | *Renardite* | Phos. | $Y = c$. G. = 4. X = colorless, Y and Z = yellow | 148 |

**Group 34a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically +

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 dist. | Prism. | 47° | Orth. | *Austinite* | Arsen. | $Y=a$; $Z=b$. G. = 4.12 | *4 |
| Plates | 100 | Lg. | Orth. | *Dumontite* | Phos. | $Y=c$; $Z=a$ | 148 |

**Group 34b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $Y=c$ | Ps. Tet. | Sm. | Orth. | *Allodelphite* | Sil. | G. = 3.57 | 440 |

## V. Birefringence strong: $N_g - N_p > 0.0275 < 0.0365$

**Group 37b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically −

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 | Prism. | 38° | Mon. | *Hexahydrite* | Sul. | $X \wedge c = -25°$. $Y=b$ | 106 |
| $X=b$ | Prism. | Lg. | Mon. | *Inderite* | Bor. | $Z \wedge c = 5°$ | *5 |
| 110 perf. | Prism. | 73° | Mon. | *Probertite* | Bor. | $Y=b$; $Z \wedge c = 12°–13°$ | 93 |

**Group 38b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically −

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $X=c$ | ? | 0° | Hex. | *Fluoborite* | Bor. | G. = 2.9 | 92 |

**Group 39a.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically +

A. No visible cleavage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $Z \wedge c = +28°$ | Acic. | Mod. | Mon. | *Weinschenkite* | Phos. | $X=b$. Sol. acid | 142 |

B. One or more visible cleavage directions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 perf. | ? | 90°± | Mono.? | *Tilleyite* | Sil. | $X \wedge c = 18°$. $Y=b$ | *6 |
| 010, 100 | 010 | 35° | Mono. | *Hilgardite* | Bor. | $Y=b$. $Z \wedge c = 1.5°$ | *7 |
| 001, 110 | 010 | Lg. | Tr.? | *Monetite* | Phos. | $Y=b±$. G. = 2.92 | 123 |

* K. Spangenberg: *Zent. Mineral.* 1938, A, p. 360.
** V. I. Gerasimovsky: *Trans. Lomonossov Inst. Geochem. Cryst. Mineral.*, X, 1937, p. 5.
*** M. C. Bandy: *Am. Mineral.*, XXXIII, 1938, p. 714.
*4 L. W. Staples: *Am. Mineral.*, XX, 1935, p. 112.
*5 A. Boldyrava: *Mem. Soc. Russe Mineral.*, LXVI, 1937, p. 651.
*6 E. S. Larsen and K. C. Dunham: *Am. Mineral.*, XVIII, 1933, p. 469.
*7 C. S. Hurlbut and R. E. Taylor: *Am. Mineral.*, XXII, 1937, p. 1052.

## SUPPLEMENTARY TABLE II.—BIREFRINGENCE OF MINERALS

V. Birefringence strong: $N_g-N_p>0.0275<0.0365$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | | | **Group 39b.** Refringence positive and moderate: $N_o$ or $N_m>1.59<1.66$. Optically − | | | |
| | | | | B. One or more visible cleavage directions and colorless | | | |
| X⊥0001 cl. | 0001 | 0° | Hex. | *Portlandite* | Ox. | G. = 2.33. Sol. HCl | * |
| | | | | **Group 40a.** Refringence positive and high: $N_o$ or $N_m>1.66<1.74$. Optically + | | | |
| | | | | C. Two or more visible cleavage directions | | | |
| 001, 100 | El. ∥ *b* | 35° | Mon. | *Serandite* | Sil. | $X \wedge a=-57°$. $Z=b$. G. = 3.21 | 418 |
| 110 at 87° | Prism. | 70° | Mon. | *Johannsenite* | Sil. | $Y=b$. $Z \wedge c=48°$ | ** |
| | | | | **Group 40b.** Refringence positive and high: $N_o$ or $N_m>1.66<1.74$. Optically − | | | |
| | | | | A. No visible cleavage | | | |
| ? | Fib. | Lg. | Mon. | *Lehiite* | Phos. | Lg. extinction angle. G. = 2.89 | 158 |
| 100 dist. | ? | Lg. | Mon. | *β-Uranotile* | Sil. | $X=b$. $Y \wedge c=49°$ | *** |
| | | | | **Group 41a.** Refringence positive and very high: $N_o$ or $N_m>1.74<2.00$. Optically + | | | |
| 110 at 89° | ? | Sm. | Mon. | *Clinoferrosilite* | Sil. | $Y=b$. $Z \wedge c=34.5°$ | *4 |
| 001, 110 | ? | ? | Tr.? | *Vandenbrandeite* | Uran. | Optic sign uncertain | *5 |
| | | | | **Group 41b.** Refrigence positive and very high: $N_o$ or $N_m>1.74<2.00$. Optically − | | | |
| X⊥cl. | 0001 | 0° | Rhom.? | *Taosite* | Ox. | X = yellow, Z = red brown | *6 |
| 010 dist. | ? | 53° | Orth. | *Arsenoclasite* | Arsen. | G. = 4.16. $X=b$, $Y=a$. | 133 |
| 001? | El. ∥ *b* | Mod. | Mon. | *Sursassite* | Sil. | $X \wedge a=55°$. G. = 3.25 | 438 |
| $Z=b$ | ? | 72° | Mon. | *Alleghanyite* | Sil. | $X \wedge a=35°$ | *7 |
| | | | | VI. Birefringence very strong: $N_g-N_p>0.0365<0.0545$ | | | |
| | | | | **Group 43.** Refringence negative and distinct: $N_o$ or $N_m<1.48$. Optically + or − | | | |
| ? | Tabular | 56° | Orth. | *Mercallite* | Sul. | G. = 2.31 | *8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Group 44b.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically − | | | | | |
| 0001 perf. $X = c$ | Plates ? | 0° | Rhom. | *Ungemachite* | Sul. | G. = 2.29 | *9 |
| | | 34° | Orth. | *Burkeite* | Sul. | G. = 2.57 | *10 |
| | | **Group 45a.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically + | | | | | |
| 010, 100 | 010 | 73° | Tr. | *Gordonite* | Phos. | $X \perp 010 \pm$. G. = 2.28 | 157 |
| | | **Group 45b.** Refringence positive and low: $N_o$ or $N_m > 1.53 < 1.59$. Optically − | | | | | |
| $X \perp 001$ cl. | 001 | 5° | ? | *Dakeite* | Carb. | G. = 2.51. Yellow | *11 |
| | | **Group 46a.** Refringence positive and moderate: $N_o$ or $N_m > 1.59 < 1.66$. Optically + | | | | | |
| | | A. No visible cleavage | | | | | |
| $Y = b$ | El. ‖ *b* | 64° | Mon. | *Loseyite* | Carb. | G. = 3.27. Sol. HCl | 84 |
| | | B. One or more visible cleavage directions | | | | | |
| Pin. good | Crust | 80° ± | Orth. | *Louderbackite* | Sul. | G. = 2.19. Sol. $H_2O$ | 116 |
| | | **Group 47b.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically − | | | | | |
| | | B. One or more visible cleavage directions | | | | | |
| $X \perp 001$ cl. | ? | 0° | Tet. | *Bandylite* | Bor. | G. = 2.81 | *12 |
| | | **Group 48a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically + | | | | | |
| $Z = b$ | Var. | 40° | Mon.? | *Plumbosynadelphite* | Arsen. | G. = 3.79 | *13 |

* C. E. Tilley: *Mineral. Mag.*, XXIII, 1933, p. 419.
** W. T. Schaller: *Am. Mineral.*, XVIII, 1933, p. 1131; XXIII, 1938, p. 575.
*** R. Nováček: *Mineral. Abst.*, VI, 1935, p. 148.
*4 N. L. Bowen: *Am. Jour. Sci.*, XXX, 1935, p. 481.
*5 A. Schoep: *N. Jahrb. Mineral.*, 1933, I, p. 250.
*6 J. de Lapparent: *Comp. Rend.*, 201, 1935, p. 154.
*7 A. F. Rogers: *Am. Mineral.*, XX, 1935, p. 25.
*8 G. Carobbi: *Mineral. Abst.*, VI, 1935, p. 148.
*9 M. A. Peacock and M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 314.
*10 W. F. Foshag: *Am. Mineral.*, XX, 1935, p. 50.
*11 E. S. Larsen and F. A. Gonyer: *Am. Mineral.*, XXII, 1937, p. 561.
*12 C. Palache and W. F. Foshag: *Am. Mineral.*, XXIII, 1938, p. 85 (also p. 704).
*13 C. S. Hurlbut: *Am. Mineral.*, XXII, 1937, p. 526.

## SUPPLEMENTARY TABLE II.—BIREFRINGENCE OF MINERALS

VI. BIREFRINGENCE VERY STRONG: $N_g - N_p > 0.0365 < 0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 48b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically − | | | | | | | |
| A. No visible cleavage | | | | | | | |
| ? | Prism. | 5°± | Mon. | *Fersmanite* | Tet. | $Y=b$. $X \perp 001 \pm$. Brown | 168 |
| B. One or more visible cleavage directions | | | | | | | |
| 120 dist. | Prism. | 80° | Orth. | *Larsenite* | Sil. | G. = 5.9. $X=a$; $Y=c$ | 187 |
| Y ∥ elong. | ? | Sm. | Orth.? | *β-Uranopilite* | Sul. | Z in 010 | * |
| $Y \perp 001$ cl. | ? | 49° | Orth. | *Talasskite* | Sil. | $X=b$. G. = 4.1 | ** |
| 100 perf. | Ps. Orth. | 49° | Tr. | *Yeatmanite* | Sil. | G. = 4.8. $Z \wedge c = 3.5°$ | *** |
| **Group 49b.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically − | | | | | | | |
| ? | Tab. | Lg. | Orth.? | *Duftite* | Phos. | G. = 6.19. Sol. acid | 132 |
| ? | Fib. | Sm. | Mon. | *Fervanite* | Van. | Extinction slightly inclined | 142 |
| VII. BIREFRINGENCE EXTREME: $N_g - N_p > 0.0545$ | | | | | | | |
| **Group 51a.** Refringence negative and low: $N_o$ or $N_m > 1.48 < 1.54$. Optically + | | | | | | | |
| 110 perf. | Prism. | 53° | Orth. | *Nesquehonite* | Carb. | $X=a$. $Y=c$. G. = 1.85 | 84 |
| 010 perf. | ? | 42° | Mon. | *Ginorite* | Bor. | $Y=b$. G. = 2.09 | *4 |
| 010, 111 | Tablets | 75° | Mon. | *Nahcolite* | Carb. | $X \wedge c = +27.5°$ | *5 |
| ? | ? | 60° | Tr. | *Ammonioborite* | Bor. | Ext. 7° to 13° | 91 |
| **Group 52a.** Refringence positive and low: $N_o$ or $N_m > 1.54 < 1.59$. Optically + | | | | | | | |
| $Z=c$ | Acic. | 0° | Tet. | *Julienite* | CSN + | G. = 1.65. Sol. $H_2O$ | *6 |
| 010 perf. | Fib. | 37° | Mon. | *Veatchite* | Bor. | $Y=b$. $Z \wedge c = -38°$. G. = 2.69 | *7 |
| 100, 010, 001 | Prism. | 60° | Orth. | *Metasideronatrite* | Sul. | $Y=b$; $Z=c$. Yellow: $X<Y<Z$ | *8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Group 52b.** Refringence positive and low: $N_o$ or $N_m>1.53<1.59$. Optically − | | | | | | | |
| 100, 010 | Fib. | 52° | Mon. | *Alumohydrocalcite* | Carb. | Ext. at 10° to fibers | 88 |
| **Group 53a.** Refringence positive and moderate: $N_o$ or $N_m>1.59<1.66$. Optically + | | | | | | | |
| −Elong. | ? | Sm. | Orth. | *β-Ascharite* | Bor. | G. = 2.65 | *9 |
| Perf. | Prism. | Sm. | Orth. | *Ransomite* | Sul. | G. = 2.63 | 116 |
| 001, 100 | Cub. ± | Sm. | Mon. | *Guildite* | Sul. | G. = 2.72. Yellow | 117 |
| 001, 100 | Var. | Lg. | Mon. | *Krausite* | Sul. | G. = 2.84. $X\wedge c=-35°$. $Z=b$. | 115 |
| $Y=b$ | Var. | 80° | Mon. | *Szomolnokite* | Sul. | $X\wedge c=+26°$ | *10 |
| **Group 53b.** Refringence positive and moderate: $N_o$ or $N_m>1.59<1.66$. Optically − | | | | | | | |
| A. No visible cleavage | | | | | | | |
| $Y=b$ | Prism. | Lg. | Mon. | *Rogersite* | Sul. | $X\wedge c=27°$ | 109 |
| B. One or more visible cleavage directions | | | | | | | |
| 010, 110 | Var. | Mod. | Tr. | *Castanite* | Sul. | $X\wedge c$ in $010=22°$ | 110 |
| **Group 54a.** Refringence positive and high: $N_o$ or $N_m>1.66<1.74$. Optically + | | | | | | | |
| $Z=c$ | Rhom. | 0° | Hex. | *Synchysite* | Carb. | G. = 3.90 | 85 |
| 110, 001 | Curved | 75° | Orth. | *Antofagastite* | Hal. | Bluish green | *11 |
| 010, 100, 001 | ? | 50° | Tr. | *Lopezite* | Chrom. | Opt. Pl. ⊥001±. Sol. $H_2O$ | *12 |
| ? | Prism. | Mod. | Mon. | *Legrandite* | Arsen. | $X=b$. $Z\wedge c=-38°\pm$. Yellow with $Y<Z$ | 117 |

* R. Nováček: *N. Jahrb. Mineral.*, 1936, I, p. 141.
** V. D. Nikitin: *Mineral. Abst.*, VI, 1937, p. 438.
*** C. Palache, L. H. Bauer and H. Berman: *Mineral. Abst.*, VII, 1938, p. 14.
*4 G. d'Achiardi: *Mineral. Abst.*, V, 1934, p. 484.
*5 A. N. Winchell: Micro. Char. Art. Minerals, 2d Ed., New York, 1931, p. 199.
*6 A. Schoep and V. Billiet: *Zeit. Krist.*, XCI, 1935, p. 229.
*7 G. Switzer: *Am. Mineral.*, XXIII, 1938, p. 409.
*8 M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 714.
*9 M. N. Godlevsky: *Mem. Soc. Russe Mineral.*, LXVI, 1937, p. 315.
*10 M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 714.
*11 C. Palache and W. F. Foshag: *Am. Mineral.*, XXIII, 1938, p. 85.
*12 M. C. Bandy: *Am. Mineral.*, XXII, 1937, p. 929.

## SUPPLEMENTARY TABLE II.—BIREFRINGENCE OF MINERALS

### VII. BIREFRINGENCE EXTREME: $N_g - N_p > 0.0545$—*continued*

| Cleavage, Optic Orient. | Habit, etc. | 2V | System | Mineral | Chem. | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| **Group 54b.** Refringence positive and high: $N_o$ or $N_m > 1.66 < 1.74$. Optically − | | | | | | | |
| B. One visible cleavage | | | | | | | |
| X⊥001 cl. | 001 | 74° | Orth. | *Bermanite* | Phos. | $Y=b$. X=light brown, Y=pale yellow, Z=red | * |
| 010 perf. | Pyr. | Lg. | Orth. | *Butlerite* | Sul. | G.=2.55 | 108 |
| C. Two or more visible cleavage directions | | | | | | | |
| 110 at 56° | Prism. | 80°± | Mon. | *Kærsutite* | Sil. | $Y=b$; $Z \wedge c=2°\pm$ | 254 |
| **Group 55a.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically + | | | | | | | |
| A. No visible cleavage and not elongated or with negative elongation | | | | | | | |
| ? | Var. | 50° | Orth. | *Juaquinite* | Sil. | $Y=b$; $Z=c$. G.=3.89 | 417 |
| C. One or more visible cleavage directions | | | | | | | |
| 010 dist. | Prism. | Lg. | Tr. | *Rossite* | Phos. | $Z=c\pm$. G.=2.45 | 158 |
| **Group 55b.** Refringence positive and very high: $N_o$ or $N_m > 1.74 < 2.00$. Optically − | | | | | | | |
| A. No visible cleavage and uniaxial | | | | | | | |
| 0001 dist. | 0001 | 0° | Rhom. | *Argentojarosite* | Sul. | Yellow: X<Z | 114 |
| 0001 dist. | 0001 | 0° | Rhom. | *Ammoniojarosite* | Sul. | Yellow: X<Z | 114 |
| B. No visible cleavage and biaxial | | | | | | | |
| X ‖ Fib. | Fib. | Sm. | Orth.? | *Rosasite* | Carb. | X=colorless; Y=Z=pale bluish | 84 |
| C. One or two visible cleavage directions and uniaxial or 2V<40° | | | | | | | |
| X⊥100 cl. | 100 | Sm. | Orth. | *Ianthinite* | Ox. | $Y=c$. X=colorless, Y=violet, Z=dark violet | 60 |
| E. Three visible cleavage directions | | | | | | | |
| 100+ | Tab. | 64° | Mon. | *Murmanite* | Sil. | X⊥100±. G.=2.84 | ** |

**Group 56a.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically +

D. One or more visible cleavage directions and prismatic elongation

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 011; 100 part. | Prism. | ? | Orth. | *Bismutotantalite* | Tant. | G. = 8 − 8.4 | 167 |
| 100 or 110 | ? | ? | Orth. | *Curite* | Uran. | X = *c*; Z = *a*. G. = 7.19, Optic sign +? | 103 |

**Group 56b.** Refringence positive and extreme: $N_o$ or $N_m > 2.00$. Optically −

C. No visible cleavage and biaxial

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ? | ? | 40° ± | ? | *Clarkeite* | Uran. | Orange. G. = 6.39. | 111 |
| One dist. | ? | ? | Orth. | *Psittacinite* | Van. | Biaxial | 133 |

G. One or more visible cleavage directions and biaxial with inclined extinction

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 010 perf. | 010 | ? | Mon. | *Lindgrenite* | Molyb. | Green. $X \wedge c = -7°$, Z = *b* | *** |

* C. S. Hurlbut: *Am. Mineral.*, XXI, 1936, p. 656.

** A. E. Fersman: *Mineral. Abst.*, II, p. 263; N. N. Gutkova: *Mineral. Abst.*, V, 1933, p. 198.

*** C. Palache: *Am. Mineral.*, XX, 1935, p. 484.

# TABLE III.—COLOR OF MINERALS

Colorless minerals are not included in these tables, since they are so numerous that a special table would be too long to be worth while as compared with complete tables based on birefringence or refringence.

Many colored minerals are pleochroic, that is, they exhibit two different tints (true pleochroism) or shades (differential absorption) of color on rotation of the stage. Some minerals are not pleochroic, that is, they show just the same color in any section and in all positions of rotation. Isotropic minerals can not be pleochroic, but anisotropic minerals are not necessarily pleochroic (at least, not sensibly so). Accordingly, non-pleochroic colored minerals are of two kinds, isotropic and anisotropic.

Pleochroic minerals exhibit two (or more) different tints or shades [1] of color when the transmitted light vibrates first in one and then in a different unlike crystallographic direction. For example, a mineral shows two different tints when it is yellow for light vibrating parallel with the vertical axis and green for light vibrating normal thereto; it shows two different shades of color when it is pale blue (or red, etc.) in one position and dark blue (or red, etc.) in another position of rotation.

Minerals show all possible tints and shades of color, but the colors which are so common as to be important are: yellow, brown, red, blue, and green. A few minerals are gray in thin section.

The following tables are intended for use in the microscopic study of minerals; therefore minerals are included in the tables wholly on the basis of optic properties as observed in thin section or fine powder. For example, sulphur has a yellow color as observed in mass, but it is not included in the table of yellow minerals beginning on page 82, because it is colorless as observed under the microscope. Also, minerals, whose optic properties in thin section or fine powder are unknown, are not included in the tables. For example, lorettoite is orange yellow in mass and perhaps yellow in thin section; it is not

[1] Two (or more) *shades* of color are strictly due to absorption rather than pleochroism, but may be included under pleochroism for convenience.

included in the table of yellow minerals beginning on page 83, because its pleochroic formula (if it is colored in thin section) is unknown. Again, annabergite, erinite, and cornwallite are pale green, but are omitted from the tables for the same reason.

On the other hand, minerals of variable optic properties are included in the tables in as many places as necessary to express all known variations in their properties.

In these tables "brown" includes not only light and dark brown, yellowish brown, red-brown, etc., but also shades such as cinnamon and chestnut brown; similarly, "blue" includes amethyst, indigo, lavender, lilac, purple and violet; "green" includes emerald, oil and olive, "red" includes carmine, cherry, claret, cochineal, crimson, magenta, pink, purple, rose, scarlet and vermilion; and "yellow" includes amber, canary, golden, lemon, ochre, orange, straw and wine colors.

For methods of estimating or measuring the index of refraction of minerals see the fifth edition of Part I, pages 75–85, 228–239 and 248–253.

For methods of estimating or measuring the birefringence of minerals see Part I, pages 116–124, and 135–137.

For definitions of X, Y, and Z see Part I, pages 117 and 160.

For methods of distinguishing between X, Y, and Z see Part I, pages 124, 130, 137, and 211.

For methods of determining pleochroic formulas, see Part I, pages 170, 171, 204, and 211.

For methods of determining the optic sign, see Part I, pages 129–132, 138, 148–154, 169, 206–213.

For methods of estimating or measuring the optic axial angle, see Part I, pages 186–189, 211, 226, and 245.

For methods of measuring extinction angles, see Part I, pages 126, 137, 173, 174, and 178.

Experienced mineralogists will realize that color is not a reliable means for identifying minerals. Many minerals may exhibit nearly any color, depending upon the presence or absence of small amounts of impurities or substances in crystal solution. Even though color in thin section is a more reliable guide than color in mass, it is not wise to rely wholly upon this table in the identification of unknown minerals. Nevertheless, color is so easily observed that this table seems desirable in spite of its inherent weakness.

Of course the intensity of color in minerals is even less constant than the color itself; nevertheless, some minerals are so often dark

colored, like biotite, or light colored, like ordinary chlorite, that it seems desirable to recognize this condition in the tables even though a color given as dark in the tables, for a certain mineral, may be light in that mineral in some cases, and *vice versa.* Accordingly, names of colors which usually appear notably dark in a given mineral are printed in bold-face type and those which usually appear light are printed in italics.

Names of minerals which are very common or very important are printed in bold-faced type, while names of rare minerals are printed in italics. Some unusually long mineral names are abbreviated to save space.

The tables based on color are arranged on the following outline: (the subdivisions are based on birefringence and the minerals in each subdivision are arranged in the order of increasing refringence).

## COLORED MINERALS

I. Minerals pleochroic in yellow and blue.
II. Yellow minerals, not pleochroic, and isotropic.
III. Yellow minerals, not pleochroic, but anisotropic.
IV. Yellow minerals, pleochroic in yellow (including orange to colorless).
V. Minerals pleochroic in yellow and brown.
VI. Minerals pleochroic in yellow and red.
VII. Brown minerals, not pleochroic and isotropic.
VIII. Brown minerals, not pleochroic, but anisotropic.
IX. Brown minerals, pleochroic in brown.
X. Minerals pleochroic in brown and red.
XI. Red minerals, not pleochroic and isotropic.
XII. Red minerals, not pleochroic, but anisotropic.
XIII. Red minerals, pleochroic in red.
XIV. Minerals pleochroic in red and blue.
XV. Minerals pleochroic in brown and blue.
XVI. Blue minerals, not pleochroic and isotropic.
XVII. Blue minerals, not pleochroic, but anisotropic.
XVIII. Blue minerals, pleochroic in blue.
XIX. Minerals pleochroic in blue and green.
XX. Green minerals, not pleochroic and isotropic.
XXI. Green minerals, not pleochroic, but anisotropic.
XXII. Green minerals, pleochroic in green.
XXIII. Minerals pleochroic in green and yellow.
XXIV. Minerals pleochroic in green and brown.
XXV. Minerals pleochroic in green and red.
XXVI. Gray minerals.

## TABLE III.—COLOR OF MINERALS

### I. Minerals Pleochroic in Yellow and Blue

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| (a) Birefringence very weak or weak; $N_g-N_p<0.0095$ | | | | | | | | |
| 1.55± | *Yellow* | *Blue* | **Cordierite** * | Sil. | − | 60° | Y=*violet*. Ps. Hex. twin. | 307 |
| 1.6± | Yellowish | **Blue** | *Aerinite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 285 |
| 1.66± | Yellow | **Violet** | *Crossite* | Sil. | − | Sm. | Y=blue. X∧*c*=70°± | 259 |
| 1.69± | **Gr.-blue** | Gr.-yellow | Arfvedsonite | Sil. | − | Lg. | Y=blue. X∧*c*=10°± | 257 |
| 1.695 | **Blue** | Blue-gray | **Riebeckite** | Sil. | − | Lg. | Y=br.-yellow. 110 cl. | 257 |
| 1.72 | *Gr.-yellow* | Gr.-blue | *Sapphirine* * | Sil. | − | 69° | Y=gr.-blue. Z∧*c*=10°± | 427 |
| (b) Birefringence moderate: $N_g-N_p>0.0095<0.0185$ | | | | | | | | |
| 1.592 | *Blue* | Gr.-yellow | *Torbernite* | Phos. | − | 0°± | X⊥001 cleav. G.=3.2 | 145 |
| 1.64± | Yellowish | Blue | Glaucophane | Sil. | − | 45°± | Y=*violet*. Z∧*c*=5°± | 258 |
| 1.685 | *Yellow* | *Greenish* | **Axinite** * | Sil. | − | 75°± | Y=blue. X⊥011± | 425 |
| 1.70± | *Red* | *Blue* | **HYPERSTHENE** | Sil. | − | 70°± | Y=yellow. X=*a*. Z=*c* | 219 |
| 1.72 | Olive green | *Yellow* | Chloritoid | Sil. | − | 50°± | Y=blue. 001 cleav. | 438 |
| (c) Birefringence rather strong: $N_g-N_p>0.0185<0.0275$ | | | | | | | | |
| 1.623 | Blue | *Gr.-yellow* | *Bazzite* | Sil. | − | 0° | Hex. G.=2.8. Insol. | 414 |
| 1.63± | *Gr.-yellow* | Gr.-blue | **Pargasite** | Sil. | + | 60°± | Y=green. Z∧*c*=28°± | 247 |
| 1.638 | *Yellowish* | **Blue** | Glaucophane | Sil. | − | 45° | Y=**violet.** Z∧*c*=5°± | 258 |
| 1.66± | *Yellow* | *Blue* | **Sillimanite** * | Sil. | + | 30° | Y=*green*. Y=*a*. Z=*c* | 200 |
| 1.67± | *Yellow* | **Blue, green** | **HORNBLENDE** | Sil. | − | 80°± | Y=green. Y=*b*. Z∧*c*=20°± | 247 |
| 1.674 | *Blue* | Colorless | Lawsonite * | Sil. | + | 84° | Y=*yellow*. X=*a*. Z=*c* | 430 |
| (d) Birefringence strong to extreme: $N_g-N_p>0.0275$ | | | | | | | | |
| 1.668 | **Blue** | Yel.-green | *Symplesite* | Arsen. | − | 87° | Y=*gr.-yellow*. Z∧*c*=32° | 126 |
| 1.722 | **Violet** | Yellowish | Diaspore | Ox. | + | 84° | Y=?. X=*c*. Z=*a* | 46 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.74± | Yellow | Red | *Piedmontite* | Sil. | + | 70°± | Y = violet. $X \wedge c = 7°$ | 315 |
| 2.146 | Red-yellow | Red-yellow | *Rafaelite* | Hal. | ? | ? | Y = **Violet**. 100 twin. | 39 |

II. Yellow Minerals, Not Pleochroic and Isotropic

| N | Color | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|---|
| 1.434 | Purple, yellow, etc. | Fluorite † | $CaF_2$ | 111 perf. | Color in spots | 31 |
| 1.485 | Yellow, blue, pink | **Sodalite** | Sil. | 110 poor | G. = 2.4. Gel. HCl | 289 |
| 1.49± | Blue, yellow, etc. | Noselite | Sil. | 110 poor | G. = 2.4. Gel. HCl | 290 |
| 1.5± | Orange | *Hisingerite* | Sil. | None | G. = 3. Dec. HCl | 415 |
| 1.50± | Blue, yellow, etc. | Hauynite | Sil. | 110 poor | G. = 2.4. Gel. HCl | 290 |
| 1.64± | Ocher-yellow | *Lagonite* | Bor. | None | Soft. Very rare | 94 |
| 1.64± | Brown, yellow | *Griphite* | Phos. | None | G. = 3.4. Sol. HCl | 155 |
| 1.65± | Yellow± | *Diadochite* | Sul. | None | Opaline | 121 |
| 1.652± | Green, yellow | *Greenalite* ‡ | Sil. | None | G. = 2.8+. Sol. HCl | 413 |
| 1.7± | Yellow, brown | *Thorite* | $ThSiO_4$ | None | G. = 5.3± | 185 |
| 1.73± | Red, blue, etc. | Spinel † | $MgAl_2O_4$ | 111 poor | G. = 3.6. H. = 8 | 62 |
| 1.739 | Yellowish | *Helvite* | Sil. | 111 poor | G. = 3.2. Gel. HCl | 201 |
| 1.75± | Yellow | *Tritomite* | Sil. | None | G. = 4.2. Gel. HCl | 420 |
| 1.75± | *Yellow, brown* | **Grossularite** † | Sil. | None | G. = 3.5±. Insol. | 180 |
| 1.87± | Yellow, brown | **Andradite** | Sil. | None | G. = 4±. Insol. | 180 |
| 2.1± | Yellow to red | **Limonite** ‡ | Fe, O, H | None | G. = 3.8± | 47 |
| 2.14± | Amber | *Yttrocrasite* | Tit. | ? | G. = 4.8. Sol. $H_2SO_4$ | 167 |
| 2.346 | Yellow | *Marshite* | CuI | 110 | Red when heated | 30 |
| 2.4± | Brown, yellow | Sphalerite | ZnS | 110 perf. | G. = 4.1. Sol. HCl | 19 |
| 2.49 Li | Yellow ± | *Eglestonite* | $Hg_4OCl_2$ | None | G. = 8.3. Volatile | 37 |

* Usually colorless in section of standard thickness (.02-.03 mm.); pleochroic in thicker sections.

† Often colorless.

‡ Often opaque on account of surface reflection and refraction.

## TABLE III.—COLOR OF MINERALS

### III. Yellow Minerals, Not Pleochroic, But Anisotropic

| $N_o$ or $N_m$ | Color | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | (a) Birefringence very weak or weak: $N_g-N_p<0.0095$ | | | | | |
| 1.75± | *Yellow, brown* | **Grossularite** * | Sil. | ± | Var. | No cleav. G.=3.5± | 180 |
| 1.87± | Yellow, brown | **Andradite** | Sil. | ± | Var. | No cleav. G.=4± | 180 |
| 2.21 | *Yellow* (zones) | *Weslienite* | Antim. | + | Sm. | Abn. int. colors | 160 |
| 2.506 | Yellow, orange | *Greenockite* | CdS | + | 0° | $10\bar{1}0$ cleav. G.=4.8 | 21 |
| | | (b) Birefringence moderate or rather strong: $N_g-N_p>0.0095<0.0275$ | | | | | |
| 1.623 | Lemon yellow | *Uranopilite* | Sul. | + | Lg. | Abn. int. colors | 117 |
| 1.666 | *Yellow* | *Johnstrupite* * | Sil. | + | 70° | 100 cleav. G.=3.3 | 423 |
| 1.73 | *Yellow* | *Melanocerite* | Sil. | − | 0° | No cleav. G.=4.13 | 420 |
| 1.733 | ***Yellowish*** | *Hematolite* | Arsen. | − | 0° | 0001 cleav. G.=3.4 | 153 |
| 2.18 | *Yellow* | *Kleinite* | $Hg_2OCl_2$ | − | Sm. | One cleav. G.=7.98 | 38 |
| | | (c) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.68± | Reddish yellow | *Erythrosiderite* | Hal. | − | 65°± | X=*a*. Y=*c*. Deliques. | 35 |
| 1.763 | Canary yellow | *Dewindtite* | Phos. | + | Lg. | X=*a*. Y=*c*. 100 cleav. | 148 |
| 1.997 | *Brown, yellow* | Cassiterite | $SnO_2$ | + | 0° | G.=7±. Zonal | 52 |
| 2.19 | *Yellow, brown* | *Baddeleyite* | $ZrO_2$ | − | 30° | $X\wedge c=12°$. 001 cleav. | 60 |
| 2.20 | Canary yellow | *Tripuhyite* | Antim. | + | Sm. | G.=5.8. In gravels | 160 |
| 2.24 | Golden yellow | *Tungstite* | $WO_3.H_2O$ | − | Sm. | X⊥001 cleav. | 60 |
| 2.4± | Green-yellow | *Stibiotantalite* | Tant. | + | 75°± | X⊥100 cleav. Z=*c* | 167 |
| 2.50 | Yellow | *Montroydite* | HgO | + | Lg. | 010 cleav. Sol. HCl | 41 |
| 2.61 | **Brown, yellow** | **Rutile** † | $TiO_2$ | + | 0° | Tet. prism. G.=4.2 | 50 |
| 2.65 Li | Yellow-orange | *Lithargite* | PbO | − | 0° | 110 cleav. G.=9.13 | 41 |

IV. Yellow Minerals, Pleochroic in Yellow (Including Orange to Colorless)

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (a) Birefringence very weak or weak: $N_g-N_p<0.0095$ | | | | | |
| 1.525± | Colorless | *Golden* | Sepiolite ‡ | Sil. | − | Sm. | Y=Z. Z ∥ fibers | 410 |
| 1.58± | *Yellow* | *Golden* | Beryl ‡ | Sil. | − | 0° | Hex. G.=2.8± | 212 |
| 1.61± | Colorless | *Yellow* | *Eudialite* ‡ | Sil. | + | 0° | 0001 cleav. Gel. HCl | 417 |
| 1.63± | *Yellow* | Colorless | *Eucolite* ‡ | Sil. | − | 0° | 0001 cleav. Gel. HCl | 417 |
| 1.72 | *Yellow* | Colorless | Vesuvianite | Sil. | − | 0° | Tet. G.=3.4. Contacts | 207 |
| >1.74 | *Yellow* | Br. yellow | *Schafarzikite* | Phos. | + | 0° | 110 cleav. G.=4.3 | 122 |
| 1.915 | *Yellow* | ? | *Huegelite* | Van. | + | Sm. | Y=orange. Abn. int. colors | 127 |
| 1.93 | Golden: X and Y<Z | | *Corkite* | Sul. | − | 0° | 0001 cleav. G.=4.2± | 119 |
| | | | (b) Birefringence moderate: $N_g-N_p>0.0095<0.0185$ | | | | | |
| 1.545 | Colorless | *Yellow* | **Chrysotile** ‡ | Sil. | + | 30°± | Y=Z. Z ∥ fibers | 260 |
| 1.591 | *Yellow* | Yellow | *Metavoltine* | Sul. | − | 0° | G.=2.53. Scaly | 114 |
| 1.623 | Colorless | *Yellow* | Uranocircite | Arsen. | − | 10°± | X⊥001 cleav. Y=*b* | 147 |
| 1.637 | ? | Colorless | Barite ‡ | Sul. | + | 37° | Y=**yellow.** X⊥001 cl. | 100 |
| 1.654 | Colorless | Red-yellow | *Hureaulite* | Phos. | − | 74° | Y=*yellow.* Z∧*c*=75° | 124 |
| 1.654 | Colorless | *Yellow* | Phenakite ‡ | Sil. | + | 0° | 11$\bar{2}$0 cleav. G.=3.0 | 185 |
| 1.657 | Colorless | *Br. yellow* | *Seybertite* | Sil. | − | 5° | Y=Z. X⊥001 cleav. | 286 |
| 1.66 | Colorless | Orange | *Salmonsite* | Phos. | + | Lg. | Y=yellow. Z ∥ fibers | 156 |
| 1:666 | *Yellow* | *Gr. yellow* | *Johnstrupite* ‡ | Sil. | + | 70° | Y=*br. yellow.* Y=*b* | 423 |
| 1.668 | *Yellow:* X<Y<Z | | *Rinkite* | Sil. | + | 43° | X=*b*. Y∧*c*=8°. 100 cl. | 423 |
| 1.681 | *Yellow* | Colorless | *Prismatine* ‡ | Sil. | − | 30°± | Y=*br. yellow.* X=*c* | 421 |

* Often colorless.

† Often opaque in standard sections; colored in extremely thin sections.

‡ Usually colorless in sections of standard thickness (.02–.03 mm.); pleochroic in thicker sections.

## TABLE III.—COLOR OF MINERALS

### IV. Yellow Minerals, Pleochroic in Yellow (Including Orange to Colorless)—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (b). Birefringence moderate: $N_g-N_p>0.0095<0.0185$—*continued* | | | | | |
| 1.686 | Colorless | ? | *Titanoelpidite* | Sil. | + | Mod. | Y=yellow. X=*b*. Y=*c* | 400 |
| 1.695 | Colorless | *Yellow* | *Guarinite* | Sil. | + | 90°± | Y=*yellowish*. G.=3.27 (=Hainite?) | 406 |
| 1.75 | Colorless | Golden | **Staurolite** | Sil. | + | 88° | Y=*yellowish*. Y=*a*. Z=*c* | 202 |
| 1.96 | Golden: X and Y<Z | | *Beudantite* | Sul. | − | Mod. | 0001 cleav. G.=4.1 | 119 |
| 2.135 | Colorless± | *Yellow* | *Mimetite* | Arsen. | − | 0° | Hex. Prism. G.=7.1 | 132 |
| 2.265 | *Yellow* | Golden | *Descloizite* | Van. | − | Lg. | Y=gr.-yellow. X=*c* | 133 |
| | | | (c) Birefringence ratner strong: $N_g-N_p>0.0185<0.0275$ | | | | | |
| 1.57 | *Yellowish* | **Golden** | *Xylotile* | Sil. | + | Sm. | Y=X. Z ‖ fib. G.=2.5± | 261 |
| 1.574 | *Yellow* | **Yellow** | *Basseite* | Phos. | − | 62° | Y=yellow. X⊥010 cleav. | 146 |
| 1.575 | Colorless | Golden | *Autunite* | Phos. | − | 33° | Y=golden. X⊥001 cleav. | 146 |
| 1.586 | Colorless± | *Yellow* | *Uranospinite* | Arsen. | − | 46° | Y=Z. X⊥001 cleav. | 147 |
| 1.6± | *Yellow* | Golden | Bowlingite | Sil. | − | Sm. | Y=yellow. X⊥001 cleav. | 437 |
| 1.613 | *Gr.-yellow* | *Br.-yellow* | *Meliphanite* * | Sil. | − | 0° | Tet. Pyram. 001 cleav. | 210 |
| 1.62 | *Yellowish* | Yellow | *Nontronite* | Sil. | − | Var. | Y=orange. X⊥001 cleav. | 415 |
| 1.63 | *Golden* | Colorless | *Carpholite* | Sil. | − | 60° | Y=X. Y=*a*. Z=*c*. 010 cleav. | 431 |
| 1.65± | Colorless± | Yellow | **Tourmaline** | Sil. | − | 0° | Max. abs.⊥elong. | 301 |
| 1.653 | *Yellow* | Yellow | *Plumbogummite* | Phos. | + | 0° | G.=4.5. Sol. $HNO_3$ | 153 |
| 1.666 | Colorless | Yellow | *Uranophane* | Sil. | − | 40°± | Y=*yellow*. Abn. int. colors. | 441 |
| 1.716 | *Yellow* | Wine yellow | *Woehlerite* | Sil. | − | 75° | Y=X. X∧*c*=45°. 010 cl. | 441 |
| 1.9± | **Br.-yellow** | *Yellow* | *Ardennite* | Sil. | + | 70° | Y=golden. Y⊥010 cleav. | 440 |
| 2.356 | Yellow: X>Z | | *Wurtzite* | ZnS | + | 0° | 10$\bar{1}$0 cleav. G.=4± | 20 |

(d) Birefringence strong: $N_g - N_p > 0.0275 < 0.0365$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.510 | *Yellow* | **Yellow** | *Uranospathite* | Phos. | − | 69° | Y = **yellow**. X ⊥ 001 cleav. | 146 |
| 1.57± | Colorless | *Br.-yellow* | **Phlogopite** | Sil. | − | 10° | Y = Z. X ⊥ 001 cleav. | 272 |
| 1.576 | Gr. yellow | *Yellow±* | *Parsettensite* | Sil. | − | 0° | 0001 cleav. Dec. HCl | 407 |
| 1.62± | *Golden* | *Yellow* | Chondrodite | Sil. | + | 80°± | Y = *yellow±*. X ∧ *a* = 30° | 196 |
| 1.63± | *Golden* | *Yellow* | Humite | Sil. | + | 68° | Y = colorless. X = *a*. Z = *b* | 197 |
| 1.65± | *Yellow* | *Br.-yellow* | Cummingtonite | Sil. | + | 80°± | Y = *yellow*. Z ∧ *c* = 15° | 243 |
| 1.67± | *Golden* | *Yellow* | Clinohumite | Sil. | + | 76° | Y = colorless. X ∧ *a* = 10° | 197 |
| 1.68± | Br. yellow | Br. yellow | *Erythrosiderite* | Hal. | − | 65° | Y = red-yellow. X = *a*. Y = *c* | 35 |
| 1.687 | *Yellow*: X and Y < Z | | *Rosenbuschite* | Sil. | + | 60° | 001 cleav. Z ∧ *c* = 13° | 419 |
| 1.687 | Colorless | Yellow | *Schroeckingerite* | Carb. | − | 40° | Abn. int. colors. 010 cl. | 86 |
| 1.72 | Colorless± | Yellow | *Phosphuranylite* | Phos. | − | 0° | X ⊥ 010 plates. Sol. HCl | 147 |
| 1.74 | *Yellow* | Straw yellow | *Molengraafite* | Sil. | + | 28° | Y = colorless. Z ∧ *c* = Sm. | 418 |
| 1.75 | *Yellow* | Golden | *Lamprophyllite* | Sil. | + | 40° | Y = X. X ⊥ 010 cleav. | 418 |
| 1.75 | Colorless | Golden | *Laavenite* | Sil. | − | 80° | Y = X. 100 cleav. X ∧ *c* = 20° | 420 |
| 2.27 | Br.-yellow: X < Z | | *Raspite* | $PbWO_4$ | + | Sm. | 100 cleav. X ∧ *c* = Lg. | 101 |

(e) Birefringence very strong: $N_g - N_p > 0.0365 < 0.0545$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.534 | Colorless± | *Yellow* | *Fibroferrite* | Sul. | + | 0°± | Y = colorless±. Z ∥ fib. | 109 |
| 1.535 | Colorless | Orange-yellow | *Quetenite* | Sul. | + | 34° | Y = X. 110 cleav. G. = 2.12 | 116 |
| 1.59± | Colorless | *Yellow* | **Fe-muscovite** | Sil. | − | Sm. | Y = Z. X ⊥ 001 cleav. | 268 |
| 1.595 | Colorless | Yellow | *Johannite* | Sul. | + | Lg. | Y = *yellow*. X = *b*± | 118 |
| 1.635 | Colorless | Yellow | *Sklodowskite* | Sil. | − | Lg. | Y = *yellow*. Y ⊥ 001 cleav. | 441 |
| 1.662 | Colorless | ? | *Soddite* | Ox. | + | ? | Y = yellow. X = *a*. Z = *c* | 61 |
| 1.673 | Orange-yellow | Colorless | *Durangite* | Arsen. | − | 57° | Y = *orange-yellow* | 151 |
| 1.697 | Colorless | *Yellow* | Grunerite | Sil. | − | 82° | Y = X. Y = *b*. Z ∧ *c* = 12°± | 242 |
| 1.714 | Colorless | Yellow | *Schoepite* | $UO_3 \cdot 2H_2O$ | − | Lg. | Y = Z. X ⊥ 001 cleav. | 60 |
| 1.77 | ? | **Yellow** | *Becquerelite* | $UO_3 \cdot 2H_2O$ | − | Sm. | Y = yellow. X ⊥ 001 cleav. | 60 |

* Usuallly colorless in standard sections; may be pleochroic in thicker sections.

## TABLE III.—COLOR OF MINERALS

### IV. Yellow Minerals, Pleochroic in Yellow (Including Orange to Colorless)—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| (e) Birefringence very strong: $N_g-N_p>0.0365<0.0545$—*continued* | | | | | | | | |
| 1.79 | Yellow | Gr.-yellow | Monazite | Phos. | + | 12° | Y=**yellow**. $Z\wedge c=4°$ | 138 |
| 1.815 | *Yellow* | Orange | *Pascoite* | Van. | − | 50° | Y=yellow. X=*b*. $Z\wedge c=8°$ | 160 |
| 1.864 | *Yellowish* | *Yellowish* | *Knebelite* * | Sil. | − | 50°± | Y=*yellow*. X⊥010 cleav. | 193 |
| 1.877 | *Gr.-yellow* | *Gr.-yellow* | **Fayalite** * | Sil. | − | 50° | Y=*orange*. X⊥010 cl. | 192 |
| (f) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | | | | |
| 1.525 | Colorless | *Amber-yellow* | *Sideronatrite* | Sul. | + | 58° | Y=*yellow*. X⊥100 cl. | 115 |
| 1.54± | Yellow | Gr.-yellow | *Mono. copiapite* | Sul. | + | Lg. | Y=colorless. $Z\wedge c=50°$ | 108 |
| 1.580 | *Yellowish* | Orange | *Cacoxenite* | Phos. | + | 0° | Z ∥ fib. G.=3.38 | 143 |
| 1.605 | Colorless± | Orange | *Amarantite* | Sul. | − | 28° | Y=*orange*. 100, 010 cl. | 109 |
| 1.66 | Colorless | Yellow | *Stewartite* | Phos. | − | Lg. | Y=*yellow*. 010 cleav. | 128 |
| 1.672 | *Yellow* | *Golden* | *Parisite* * | Carb. | + | 0° | 0001 cleav. G.=4.4 | 85 |
| 1.680 | Colorless± | Yellow | *Zippeite* | Sul. | − | Lg. | Y=yellow. X⊥010 cleav. | 110 |
| 1.703 | **Golden** | Lemon yellow | *Astrophyllite* | Sil. | + | 75°± | Y=orange. X⊥010 cl. | 417 |
| 1.734 | Yellow: X<Y<Z | | *Curtisite* | $C_{60}H_{40}O$ | + | 83° | Z⊥001 cleav. | 18 |
| 1.755 | *Yellow* | Br. yellow | *Vegasite* | Sul. | + | 0° | Z⊥0001 plates | 116 |
| 1.76± | Clear yellow | Gray-yellow | *Ferrimolybdite* | Molyb. | + | 28° | Y=X. X=*b*. Z ∥ fib. | 108 |
| 1.760 | Br.-yellow | Gr.-yellow | *Cordylite* * | Carb. | − | 0° | 0001 cleav. G.=4.3 | 86 |
| 1.820 | Colorless | Yellow | *Jarosite* | Sul. | − | 0° | 0001 cleav. G.=3.2 | 114 |
| 1.832 | Colorless | *Yellow* | *Natrojarosite* | Sul. | − | 0° | 0001 cleav. G.=3.18 | 114 |
| 1.9± | Gray-yellow | Yellow | *Carnotite* | Van. | − | 45° | Y=Z. X⊥001 cleav. | 148 |
| 1.9± | Colorless± | Yellow | *Tyuyamunite* | Van. | − | 45° | Y=Z. X⊥001 cleav. | 147 |
| 1.905 | *Br. yellow* | *Yellow* | **Titanite** * | Sil. | + | 28° | Y=X. Str. disp. | 204 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.95± | Colorless | *Yellow* | *Durdenite* | Tel. | − | 23° | Y=*yellow*. X=*c* | 118 |
| 1.997 | *Br.-yellow* | *Golden* | Cassiterite | $SnO_2$ | + | 0° | G.=7±. Zonal. | 52 |
| 2.20 | Yellow | Br.-yellow | *Lepidocrocite* | FeO(OH) | + | 83° | Y=orange. X⊥010 cl. | 48 |
| 2.24 | Yellow: X>Y>Z | | *Tungstite* | $WO_3 \cdot H_2O$ | − | Sm. | X⊥001 cleav. Sol. KOH | 60 |
| 2.30 | Yellow | Orange | **Goethite** | FeO(OH) | − | Var. | Y=br.-yellow. Extr. disp. | 47 |
| 2.354 | *Yellow* | *Orange* | Vanadinite | Van. | − | 0° | Hex. Prism. Dec. HCl | 131 |
| 2.37 | Gr.-yellow | Red-yellow | *Crocoite* | $PbCrO_4$ | + | 57° | Y=? Y=*b*. Z∧*c*=6° | 101 |
| 2.402 | Yellow, etc.: X<Z | | Wulfenite | $PbMoO_4$ | − | 0° | Tet. 111 cleav. G.=6.9 | 98 |
| 2.56 | *Yellow* | *Orange* | *Octahedrite* | $TiO_2$ | − | 0° | 001 cleav. G.=3.9. Insol. | 53 |
| 2.58 | Orange | Yellow | *Brookite* | $TiO_2$ | + | Var. | Y=X. Abn. int. colors | 59 |
| 2.61 Li | *Yellow* | Yellow | *Massicotite* | PbO | + | Lg. | Y (or X?)⊥100 cleav. | 41 |
| 2.61 | Yellow | **Br.-yellow** | **Rutile ‡** | $TiO_2$ | + | 0° | Tet. Prism. G.=4.2 | 50 |
| 2.72+ | Yellow: X>Y and Z | | Orpiment * | $As_2S_3$ | + | Sm. | X⊥010 cleav. Z=*a*± | 25 |

V. Minerals Pleochroic in Yellow and Brown

(a) Birefringence very weak to moderate: $N_g - N_p < 0.0185$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.543 | *Yellow* | *Yel.-brown* | **Cordierite** * | Sil. | − | 60°± | Y=*brown*. Ps. Hex. twin. | 307 |
| 1.62 | Yel.-brown | Yellow | *Nontronite* | Sil. | − | Var. | Y=? X⊥001 cleav. | 415 |
| 1.620 | *Red-brown* | *Yellow* | *Goyazite* * | Phos. | + | 0° | 0001 cleav. | 153 |
| 1.685 | *Brown* | *Olive-yellow* | **Axinite** * | Sil. | − | 75° | Y=*violet*. X⊥011± | 425 |
| 1.72 | *Br.-yellow* | *Yel.-brown* | Vesuvianite * | Sil. | − | 0° | Poor cleav. G.=3.4 | 207 |

(b) Birefringence rather strong: $N_g - N_p > 0.0185 < 0.0275$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.64 | *Brown* | *Yellow* | **Anthophylite** * | Sil. | + | Lg. | Y=X. Z=*c*. 110 cleav. | 240 |
| 1.65 | *Yellow* | **Brown** | **Tourmaline** | Sil. | − | 0° | Max. abs.⊥ elong. | 301 |
| 1.69 | *Yellow* | Brown | Barkevikite | Sil. | − | 40°± | Y=red-brown. Z∧*c*=12° | 254 |
| 1.70 | Brown | *Yellow* | **Pigeonite** | Sil. | + | Sm. | Y=X. Y=*b*. Z∧*c*=30°± | 222 |
| 2.36 | Yellow | Brown | *Wurtzite* | ZnS | + | 0° | $10\bar{1}0$ cleav. G.=4± | 20 |

* Usually colorless in sections of standard thickness (.02–.03 mm.); pleochroic in thicker sections.
‡ Often opaque in standard sections; colored in extremely thin sections.

## TABLE III.—COLOR OF MINERALS

### V. Minerals Pleochroic in Yellow and Brown—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| (c) Birefringence strong to very strong: $N_g - N_p > 0.0275 < 0.0545$ | | | | | | | | |
| 1.625 | Yellow | Brown | *Roscherite* | Phos. | − | Lg. | Y=yel.-brown. 001 cl. | 156 |
| 1.63± | Yellow | **Red-brown** | **BIOTITE** | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 227 |
| 1.63± | Yellow | **Brown** | Anomite | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 276 |
| 1.63± | Yellow | Brown | *Protolithionite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 270 |
| 1.65 | Colorless | *Yellow* | *Reddingite* | Phos. | + | 40° | Y=brown; Y⊥010 cl. | 124 |
| 1.70± | Yellow | **Green, brown** | **HORNBLENDE** | Sil. | − | 80°± | Y=brown. $Z \wedge c = 20°$± | 247 |
| 1.722 | Brown | *Yellowish* | Diaspore * | AlO(OH) | + | 84° | Y=? Y⊥010 cleav. | 46 |
| 1.734 | Rose-red | Yellow | *Adamite* | Phos. | + | 83° | Y=yel.-brown, $X=a$ | 133 |
| 1.75 | Green | Yellow | **EPIDOTE** † | Sil. | − | 70°± | Y=brown. $Z \wedge a = 25°$ | 314 |
| 1.776 | **Red-brown** | Br.-yellow | *Orientite* | Sil. | + | 67° | Y=yellow. $X=a$. $Y=c$ | 432 |
| 1.79 | Br.-yellow | Br.-yellow | Monazite * | Phos. | + | 12° | Y=red-brown. $X=b$ | 138 |
| 1.81 | X or Z=Gr.-yellow | | *Hancockite* | Sil. | − | 50° | Y=yel.-brown. 001 cl. | 316 |
| 1.845 | *Yellow* | **Red-Brown** | *Kraurite* | Phos. | + | Sm. | Y=Z. $X=a$. $Y=c$ | 142 |
| 1.9± | **Br.-yellow** | **Green** | Ilvaite ‡ | Sil. | − | Sm. | Y=**brown**. $Z=c$ | 431 |
| (d) Birefringence extreme: $N_g - N_p > 0.0545$ | | | | | | | | |
| 1.685 | *Gr.-yellow* | Brown | *Roscoelite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 270 |
| 1.69 | Yellowish | **Brown** | *Stilpnomelane* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 435 |
| 1.77 | *Yellow* | **Red-brown** | *Chalcodite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 435 |
| 1.87 | Yellow | Red-brown | *Arseniosiderite* | Arsen. | − | 0° | 001 cleav. G.=3.7± | 153 |
| 1.879 | *Br.-yellow* | Gr.-yellow | *Uvanite* | Van. | + | 52° | Y=**brown**. 2 cleav. | 148 |
| 2.19 | Brown | Brown | *Baddeleyite* | $ZrO_2$ | − | 30° | Y=gr.-yellow. $X \wedge c = 12°$ | 60 |
| 2.22 Li | Golden | Gr.-yellow | Huebnerite | $MnWO_4$ | + | 73° | Y=yel.-brown. $Z \wedge c = 20°$ | 101 |
| 2.25 | Br.-yellow: X<Z | | *Manganite* ‡ | MnO(OH) | + | Sm. | Y=X. Y⊥010 cleav. $Z=c$ | 48 |
| 2.3± | Brown | Orange | **Goethite** | FeO(OH) | − | Var. | Y=br.-yellow. Ext. disp. | 47 |

## VI. Minerals Pleochroic in Yellow and Red

(a) Birefringence very weak: $N_g - N_p < 0.0095$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.328 | Golden | Carmine | *Villiaumite* | NaF | − | ? | 100 cleav. X⊥001 | 30 |
| 1.61± | *Golden* | *Carmine* | *Eudialite* § | Sil. | + | 0° | 0001 cleav. Gel. HCl | 417 |
| 1.63± | *Carmine* | *Yellow* | *Eucolite* § | Sil. | − | 0° | 0001 cleav. Gel. HCl | 417 |
| 1.70 | **Pink** | Yellow | *Thulite* | Sil. | + | Sm. | Y=*pink*. X⊥010 cl. | 311 |

(b) Birefringence moderate: $N_g - N_p > 0.0095 < 0.0185$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.62 | *Yellow* | *Violet pink* | Topaz § | Sil. | + | 60°± | Y=*pink*. Z⊥001 cleav. | 198 |
| 1.64 | *Red* | *Yellow* | **Andalusite** § | Sil. | − | 84° | Y=Z. X=*c*. Z=*a*. 110 cl. | 201 |
| 1.67± | **Pink** | *Pink* | Lithiophilite | Phos. | + | 65°± | Y=*gr.-yellow*. Y⊥001 cl. | 149 |
| 1.70± | *Red* | *Blue* | **Hypersthene** | Sil. | − | 70°± | Y=*yellow*. X=*a*. Z=*c* | 219 |
| 1.73± | *Red-yellow*: X>Z | | Rhodonite § | Sil. | − | 76° | Y=*pink*. 110, $1\bar{1}0$ cl. | 403 |

(c) Birefringence rather strong to strong: $N_g - N_p > 0.0185 < 0.0365$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.548 | Yellow | *Orange-red* | *Botryogen* | Sul. | + | 41° | Y=*red*. X⊥010 cleav. | 116 |
| 1.660 | *Yellowish* | Colorless | *Eosphorite* | Phos. | − | 40° | Y=**pink**. Y⊥100 cleav. | 156 |
| 1.678 | **Blood-red** | Orange | *Titanclinohumite* | Sil. | + | 60°± | Y=Z. X∧001 cleav.=8°. Z=*b* | 198 |
| 1.70 | Gr.-yellow | Gr.-yellow | **AUGITE** (Ti) | Sil. | + | 60° | Y=red. X∧*c*=45°±. Y=*b* | 228 |
| 1.735 | Orange-red | *Yellow* | *Sicklerite* | Phos. | − | Lg. | Y=orange. Z⊥cleav. | 158 |
| 1.75 | *Wine yellow* | Orange-red | *Laavenite* | Sil. | − | 80° | Y=*gr.-yellow*. X∧*c*=20° | 420 |
| 1.852 | Gr.-yellow | *Pink* | *Törnebohmite* | Sil. | + | 26° | Y=bl.-green. Rare | 414 |

(d) Birefringence very strong: $N_g - N_p > 0.0365 < 0.0545$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.70 | *Yellow* | **Yellowish-red** | *Neptunite* | Sil. | + | 49° | Y=Z. Y=*b*. Z∧*c*=20° | 418 |
| 1.722 | Blue | Violet | **Diaspore** § | AlO(OH) | + | 84° | Y=yellow. Y⊥010 cl. | 46 |

* Usually colorless in sections of standard thickness (.02–.03 mm.); pleochroic in thicker sections.

† Usually pleochroic greenish to golden yellow in sections of standard thickness; colored as given above in thicker sections.

‡ Usually opaque in sections of standard thickness (.02–.03 mm.); pleochroic in extremely thin flakes or on thin edges.

§ Usually colorless in sections of standard thickness (.02–.03 mm.); colored in thicker sections.

## TABLE III.—COLOR OF MINERALS

### VI. Minerals Pleochroic in Yellow and Red—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (d) Birefringence very strong: $N_g-N_p>0.0365<0.0545$—*continued* | | | | | |
| 1.734 | Rose-red | Yellow | *Adamite* | Arsen. | + | 83° | Y=yel.-brown. X=*a* | 133 |
| 1.74 | Yellow | Red | *Piedmontite* | Sil. | + | 70°± | Y=violet. Z∧001 cleav.=32° | 315 |
| 1.75± | Yellow | Pink | **EPIDOTE** * | Sil. | − | 70°± | Y=green. Z∧001 cleav.=25° | 314 |
| 2.10 | *Orange* | **Red** | *Metahewettite* | Van. | − | 52° | Y=red. Z ‖ elong. | 160 |
| | | | (e) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.550 | Purple-red | *Yellow* | *Rhomboclase* | Sul. | + | Sm. | Y=Z. X⊥001 cleav. | 108 |
| 1.721 | *Pink* | Br.-yellow | Xenotime | Phos. | + | 0° | Tet. Prism. 110 cleav. | 138 |
| 1.875 | *Golden* | **Br.-red** | *Plumbojarosite* | Sul. | − | Sm. | Y=? 10$\bar{1}$1 cleav. G.=3.67 | 115 |
| 1.905 | *Yellow* | *Pink* | **Titanite** † | Sil. | + | 28° | Y=*gr.-pink*. Y=*b* | 204 |
| 2.18 | *Orange* | **Red** | *Hewettite* | Van. | − | Mod. | Y=X. Z ‖ elong. | 160 |
| 2.20 | Yellow | Orange-red | *Lepidocrocite* | FeO(OH) | + | 83° | Y=orange. X⊥010 cl. | 48 |
| 2.354 | Yellow | Br.-red | Vanadinite | Phos. | − | 0° | Hex. Prism. G.=7.0 | 131 |
| 2.59 | Orange-red | *Gold-yellow* | Realgar | AsS | − | 40° | Y=Z. Y⊥010 cl. X∧*c*=11° | 22 |

### VII. Brown Minerals, Not Pleochroic and Isotropic

| N | Color | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|---|
| 1.434 | Purple, brown, etc. | Fluorite | $CaF_2$ | 111 | G.=3.18. Sol. $H_2SO_4$ | 31 |
| 1.49± | Blue, brown | Noselite | Sil. | 110 poor | G.=2.3. Gel. HCl | 290 |
| 1.5± | Golden brown | *Hisingerite* | Sil. | None | G.=3. Dec. HCl | 415 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1.50± | Blue, brown | Hauynite | Sil. | 110 poor | G. = 2.4. Gel. HCl | 290 |
| 1.54± | Brown | *Neotocite* | Sil. | None | G. = 2.7. Coal-like | 298 |
| 1.54± | Green, brown | *Cornuite* | Sil. | None | G. = 2±. Conch. frac. | 413 |
| 1.635± | Reddish brown | *Pitticite* | Sul. | None | G. = 2.4±. Sol. HCl | 121 |
| 1.652 | Green, brown | *Greenalite* ‡ | Sil. | None | G. = 2.8+. Sol. HCl | 413 |
| 1.7± | Brown, yellow | *Thorite* | Ox. | ? | G. = 5.3. Also aniso. | 185 |
| 1.70± | ***Red, brown*** | **Pyrope** | Sil. | None | G. = 3.5. No cleav. | 178 |
| 1.70 | Clear brown | *Polycrase* | Colum. | None | G. = 5.0. Dec. $H_2SO_4$ | 167 |
| 1.73± | Red, brown, etc. | Spinel | $MgAl_2O_4$ | 111 poor | G. = 3.6. Oct. | 61 |
| 1.74± | Yellowish brown | Caryocerite | Sil. | None | G. = 4.3. Dec. HCl | 420 |
| 1.75± | Yellow, brown | *Tritomite* | Sil. | Poor | G. = 4.2. Gel. HCl | 420 |
| 1.75± | ***Brown*** | **Grossularite** | Sil. | None | G. = 3.5. No cleav. | 180 |
| 1.8± | Brown | *Manganspinel* | $MnAl_2O_4$ | None | G. = 4. Oct. | 62 |
| 1.81± | Brown | *Gahnite* | $ZnAl_2O_4$ | 111 poor | G. = 4.5. Oct. | 63 |
| 1.82± | ***Brown, red*** | **Almandite** | Sil. | None | G. = 4±. No cleav. | 178 |
| 1.87± | Red, brown | **Andradite** | Sil. | None | G. = 3.7. No cleav. | 180 |
| 1.9± | Red-brown | *Chevkinite* | Sil. | None | G. = 4.4 Gel. HCl | 423 |
| 2.0± | Brown, yellow | *Pyrochlore* | Tit. | 111 | G. = 4.3. Color zonal | 163 |
| 2.0± | Brownish | **Limonite** ‡ | Ox. | None | G. = 3.8. Sol. HCl | 47 |
| 2.0± | Brown | *Wiikite* | Colum. | ? | G. = 4.3±. H. = 6 | 167 |
| 2.05 | **Red-brown** | ***Risoerite*** | Tant. | ? | G. = 4.2. Sol. $H_2SO_4$ | 165 |
| 2.13 | **Brown** | *Ampangabéite* ‡ | Colum. | ? | G. = 4.1±. H. = 4 | 166 |
| 2.14 | **Brown-black** | *Blomstrandinite* * | Tit. | 010 poor | G. = 4.9. H. = 5.5 | 167 |
| 2.15± | **Brown** | *Samarskite* ‡ | Colum. | 010 poor | G. = 5.7. Insol. | 166 |
| 2.15± | Red-brown | *Euxenite* | Tit. | None | G. = 4.8. Insol. | 167 |
| 2.15± | Brown | *Fergusonite* | Colum. | 111 poor | G. = 5.8. Also biref. | 164 |
| 2.15 | Red-brown | *Yttrotantalite* | Tant. | 010 poor | G. = 5.7. Insol. | 166 |

* Usually pleochroic, greenish to golden yellow in sections of standard thickness.

† Usually colorless in sections of standard thickness (.02–.03 mm.); pleochroic in thicker sections.

‡ Usually opaque in standard sections; colored in extremely thin sections.

## TABLE III.—COLOR OF MINERALS

### VII. Brown Minerals, Not Pleochroic and Isotropic—*continued*

| N | Color | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|---|
| 2.19 | Reddish brown | *Zirkelite* | Ox. | None | G.=4.72. Oct. | 164 |
| 2.20 | Red-brown | *Thorianite* | $(Th, U)O_2$ | ? | G.=9.3. Radioactive | 50 |
| 2.215 | **Brown** | *Polymignite* | Tit. | 100 poor | G.=4.8. Insol. | 167 |
| 2.23± | Red-brown | *Eschynite* | Colum. | ? | G.=5±. Insol. | 167 |
| 2.30 | Brownish | *Knopite* | Tit. | ? | G.=4.2. Also biref. | 163 |
| 2.33 | Brown | *Dysanalite* * | Tit. | 100 | G.=4.13. Dec. HCl | 163 |
| 2.38 | Brown, gray, etc. | Perovskite | $CaTiO_3$ | 100 poor | G.=4. Also biref. | 163 |
| 2.4± | Brown, reddish | Sphalerite | ZnS | 110 | G.=4.1. Sol. HCl | 19 |
| Very high | Brown | *Blomstrandite* * | Tit. | ? | G.=4.2. H.=5.5 | 167 |

### VIII. Brown Minerals, Not Pleochroic, But Anisotropic

| $N_o$ or $N_m$ | Color | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| (a) Birefringence very weak to moderate: $N_g - N_p < 0.0185$ | | | | | | | |
| 1.65± | Brown, red | *Hellandite* | Sil. | + | 80° | X=*b*. $Z \wedge c = 44°$ | 425 |
| 1.75± | *Brown, yellow*, etc. | **Grossularite** | Sil. | ± | Var. | No cleav. G.=3.5 | 180 |
| 1.78± | Green, brown | *Gadolinite* | Sil. | + | 85° | No cleav. $Z \wedge c = 10° \pm$ | 424 |
| 1.87± | Red, brown | **Andradite** | Sil. | ± | Var. | No cleav. G.=3.7 | 180 |
| (b) Birefringence rather strong to strong: $N_g - N_p > 0.0185 < 0.0365$ | | | | | | | |
| 1.58± | Brown | *Canbyite* | Sil. | − | Sm. | $Z \perp$ cleav. | 415 |
| 1.65 | Yellow-brown | *Ferrisymplesite* | Arsen. | ? | ? | Fibrous. G.=2.89 | 126 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.733 | Brown, yellow | *Hematolite* | Arsen. | − | 0° | 0001 cleav. G. = 3.4 | 153 |
| 1.780 | Nut brown | *Caryinite* | Arsen. | + | 41° | 110, 010 cleav. X = *c* | 122 |
| 2.36± | Brown, yellow | *Wurtzite* | ZnS | + | 0° | 10$\bar{1}$0 cleav. G. = 4± | 20 |
| (c) Birefringence very strong: $N_g - N_p > 0.0365 < 0.0545$ | | | | | | | |
| 1.87 | **Red-brown** | *Synadelphite* | Arsen. | + | Sm. | X∧*c* = 45°. Z = *b* | 155 |
| 1.95± | *Brown*, etc. | **Zircon** | Ox. | + | 0° | Tet. Prism. G. = 4.7 | 183 |
| (d) Birefringence extreme: $N_g - N_p > 0.0545$ | | | | | | | |
| 1.88 | Red-brown | *Hemafibrite* | Arsen. | + | 35° | X⊥010 cleav. Y = *a* | 136 |
| 2.4± | Brown | *Stibiontantalite* | Tant. | + | 75° | X⊥100 cleav. Z = *c* | 167 |
| 2.45 | **Brown** | *Derbylite* | Tit. | + | 0° | Twin. G. = 4.5 | 162 |
| 2.46 | **Red-brown** | *Hausmannite* † | Ox. | − | 0° | 001 cleav. G. = 4.8 | 64 |

IX. Brown Minerals, Pleochroic in Brown

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| (a) Birefringence very weak to weak: $N_g - N_p < 0.0095$ | | | | | | | | |
| 1.55± | Brown | Clear brown | **Cordierite** ‡ | Sil. | − | 60°± | Y = **brown.** Ps. Hex. twin. | 307 |
| 1.64± | Brown | *Brown* | **Apatite** ‡ | Phos. | − | 0° | Hex. Prism. G. = 3.2 | 129 |
| 1.80± | Red-brown | **Brown** | Enigmatite | Sil. | + | 32° | Y = brown. Z∧*c* = 45°± | 428 |
| 2.40 Li | Red-brown | Colorless± | *Minium* | $Pb_3O_4$ | ? | 0° | Abn. int. colors | 65 |
| (b) Birefringence moderate to rather strong: $N_g - N_p > 0.0095 < 0.0275$ | | | | | | | | |
| 1.58± | Colorless | *Brown* | Vermiculite | Sil. | − | Sm. | Y = Z. X⊥001 cl. G. = 2.4 | 434 |
| 1.64 | Colorless± | *Brownish* | *Bementite* | Sil. | − | 0°± | Y = Z. X⊥001 cleav. | 409 |

* Usually opaque in standard sections; colored in extremely thin sections.
† Usually opaque in sections of standard thickness (.02–.03 mm.); colored in extremely thin flakes or on thin edges.
‡ Usually colorless in standard sections; may be colored in thicker sections.

## TABLE III.—COLOR OF MINERALS

### IX. Brown Minerals, Pleochroic in Brown—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (b) Birefringence moderate to rather strong: $N_g-N_p>0.0095<0.0275$—*continued* | | | | | |
| 1.67± | Clear brown | *Green* | **HORNBLENDE** | Sil. | − | 80° | Y=*brown*. $Z\wedge c=20°\pm$ | 247 |
| 1.67± | Red-brown | *Red-brown* | *Triplite* | Phos. | + | Lg. | Y=colorless. $Z\wedge a=42°$ | 134 |
| 1.685 | Gr.-brown | Colorless | Dumortierite | Sil. | − | 30° | Y=Z. $Z\perp 100$ cleav. $X=c$ | 422 |
| 1.69± | Brownish | **Brown** | Barkevikite | Sil. | − | 40°± | Y=red-brown. $Z\wedge c=12°$ | 254 |
| 1.7± | Brown | Red-brown | *Rhoenite* | Sil. | − | ? | Y=Z. $Z\wedge c=40°$. 110 cl. | 429 |
| 1.725 | Yel.-brown | Colorless | *Ganophyllite* | Sil. | − | Sm. | Y=Z. 001 cleav. $Z=b$ | 436 |
| 1.788 | Colorless | Red-brown | *Retzianite* | Arsen. | + | Lg. | Y=*yel.-brown*. $Z=a$ | 154 |
| 1.809 | Yel.-brown | Brown | *Warwickite* | Bor. | + | 59° | Y=red-brown. $X=c$ | 95 |
| 1.9± | Colorless | **Brown** | *Chevkinite* | Sil. | ± | Var. | Y=*brown*. No cl. | 423 |
| | | | (c) Birefringence strong to very strong: $N_g-N_p>0.0275<0.0545$ | | | | | |
| 1.535 | Colorless | Brown | *Quetenite* | Sul. | + | 34° | Y=X. 110 cleav. G.=2.12 | 116 |
| 1.6± | Colorless | Brown | **Fe-muscovite** | Sil. | − | Sm. | Y=Z. $X\perp 001$ cleav. | 268 |
| 1.60± | Colorless | Brown | Leverrierite * | Sil. | − | Sm. | Y=**brown.** $X\perp 001$ cleav. | 433 |
| 1.62± | Red-brown | *Brown* | Chondrodite | Sil. | + | Lg. | Y=X. $X\wedge a=28°$. $Z=b$ | 196 |
| 1.7± | Red-brown: $X<Y<Z$ | | Iddingsite | Sil. | ± | Var. | $X\perp 100$ cl. $Z\perp 001$ cl. | 437 |
| 1.70± | Colorless | *Brownish* | Grunerite | Sil. | − | 82° | Y=X. $Y=b$. $Z\wedge c=12°\pm$ | 242 |
| 1.73 | Colorless | Brown | *Pyrochroite* | $Mn(OH)_2$ | − | 0° | 0001 cleav. G.=3.26 | 42 |
| 1.74 | **Yel.-brown** | **Red-brown** | *Melanovanadite* | Van. | − | Sm. | Y=Z. $X\perp 010$ cleav. | 102 |
| 1.75+ | *Red-brown* | Red-brown | *Fourmarierite* | Ox. | − | Lg. | $X\perp 100$ cleav. $Z=b$ | 103 |
| 1.77 | **Brown** | *Yel.-brown* | **Acmite** | Sil. | − | 60° | Y=brown. $X\wedge c=5°\pm$ | 234 |
| 1.79 | Red-brown | Red-brown | Monazite | Phos. | + | 12° | Y=**red-brown** | 138 |
| 1.85± | *Yel.-brown* | **Brown** | *Högbomite* | Ox. | − | 0° | No cleav. G.=3.81 | 65 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.95 | **Red-brown** | Opaque± | *Manganostibite* | Antim. | − | Sm. | Y=Z. X⊥010 cleav. | 155 |
| 2.36 | **Red-brown:** X<Z | | *Langbanite* | Ox.? | − | 0° | Hex. No cleav. G.=4.7± | 66 |
| 2.39 | **Red-brown:** X<Y>Z | | *Pseudobrookite* | Ox.? | + | 50° | Y⊥001 cleav. G.=4.6± | 165 |

(d) Birefringence extreme: $N_g-N_p>0.0545$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.571 | *Brown* | *Brown* | *Roemerite* | Sul. | − | 51° | Y=brown. G.=2.15 | 117 |
| 1.637 | Colorless | **Gr.-brown** | *Ekmannite* | Sil. | − | 0°± | Y=Z. X⊥001 cleav. | 281 |
| 1.703 | Red-brown | *Yel-brown* | *Astrophyllite* | Sil. | + | 75° | Y=yel.-brown. X⊥010 cl. | 417 |
| 1.72 | *Yel. brown* | Gray-brown | Xenotime | Phos. | + | 0° | Tet. 110 cleav. G.=4.6 | 138 |
| 1.73± | *Brown* | **Brown** | **OXYHORNBLENDE** | Sil. | − | Lg. | Y=Z. Y=*b*. Z∧*c*=1°± | 252 |
| 1.898 | Colorless± | **Red-brown** | *Mazapilite* | Arsen. | − | 0°± | Orth. Prism. X=*c*. G.=3.6 | 156 |
| 2.05 | Red-brown: Y>X>Z | | *Pinakiolite* | Bor. | − | 32° | X⊥010 cleav. Y=*c* | 94 |
| 2.17 | Colorless | **Red-brown** | *Melanotekite* | Sil. | + | 67° | Y=*red-brown*. 2 cleav. | 427 |
| 2.20 | Red-brown: X<Y<Z | | *Kentrolite* | Sil. | + | 88° | X=*a*. Z=*c*. 110 cleav. | 427 |
| 2.2± | Yel. brown | **Brown** | Huebnerite | Tung. | + | Lg. | Y=brown. X⊥010 cl. | 101 |
| 2.27 | Brown | Opaque± | *Tapiolite* | Tant. | + | 0° | Tet. Prism. No cleav. | 164 |
| 2.3 | Colorless | Red-brown | *Cuprodescloizite* | Van. | − | 60°± | No cleav. X ∥ fib. | 133 |
| 2.30 | Yel.-brown | Opaque± | *Hjelmite* | Tant. | + | 0°± | Y=X. Orth. G.=5.8 | 166 |
| 2.34 | Red-brown: X>Z weak | | *Heterolite* | Ox. | − | 0° | Tet. 001 cleav. G.=4.9 | 65 |
| 2.36 | Colorless± | Red-brown | *Brackebuschite* | Van. | + | Lg. | Y=Z. Prism. Mono.? | 125 |
| 2.4± | **Red-brown** | Opaque± | Columbite † | Colum. | −? | Lg. | 100 cleav. G.=5.2± | 165 |
| 2.56 | *Brown* | Brown | *Octahedrite* | $TiO_2$ | − | 0° | 001, 111 cleav. G.=3.9 | 53 |
| 2.59 | Cin. brown | Clove brown | *Brookite* | $TiO_2$ | + | Var. | Y=Z. Poor cleav. Z=*a* | 59 |

## X. Minerals Pleochroic in Brown and Red

(a) Birefringence very weak to moderate: $N_g-N_p>0.0185$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.654 | Colorless | Red-brown | *Hureaulite* | Phos. | − | 74° | Y=rose. Z∧*c*=75°. X=*b* | 124 |
| 1.70± | Red | Green | **HYPERSTHENE** | Sil. | − | 70°± | Y=yel.-brown. X=*a* | 219 |

* Usually colorless in standard sections; may be colored in thicker sections.
† Usually opaque in standard sections; may be colored in extremely thin portions.

## TABLE III.—COLOR OF MINERALS

### X. Minerals Pleochroic in Brown and Red—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| (b) Birefringence rather strong to very strong: $N_g - N_p > 0.0185 < 0.0545$ | | | | | | | | |
| 1.57± | Reddish | Brown | **Zinnwaldite** | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 270 |
| 1.734 | Rose | Yellow | *Adamite* | Arsen. | + | 83° | Y=brown. X=*a*. Z=*b* | 133 |
| 1.81 | X or Z=rose | | *Hancockite* | Sil. | − | 50° | Y=yel.-brown. 001 cl. | 316 |
| 1.89± | Red-brown | **Red** | *Heterosite* | Phos. | − | Lg. | Y=carmine. X⊥001 cl. | 141 |
| (c) Birefringence extreme: $N_g - N_p > 0.0545$ | | | | | | | | |
| 1.774 | Flesh red | **Brown** | *Taramellite* | Sil. | + | 40° | Y=X. Z ‖ fib. G.=3.9 | 427 |
| 1.997 | *Brown* | **Red** | Cassiterite | $SnO_2$ | + | 0° | Tet. Prism. G.=7± | 52 |
| 2.2 | Red | **Blood red** | Huebnerite | Tung. | + | Lg. | X=brown. X⊥010 cl. | 101 |

### XI. Red Minerals, Not Pleochroic and Isotropic

| N | Color | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|---|
| 1.485 | Yellow, pink | **Sodalite** | Sil. | 110 poor | G.=2.3. Gel. HCl | 289 |
| 1.49± | Blue, pink, etc. | Noselite | Sil. | 110 poor | G.=2.3. Gel. HCl | 290 |
| 1.50± | Blue, pink, etc. | Hauynite | Sil. | 110 poor | G.=2.4. Gel. HCl | 290 |
| 1.72± | *Red, brown* | **Pyrope** | Sil. | None | G.=3.6±. Insol. | 178 |
| 1.73± | Red, blue, etc. | Spinel | $MgAl_2O_4$ | 111 poor | G.=3.6. Oct. | 62 |
| 1.737 | Pink | *Danalite* | Sil. | 111 poor | G.=3.43. Gel. HCl | 291 |
| 1.74± | Pink | *Tritomite* | Sil. | Poor | G.=4.2. Dec. HCl | 420 |
| 1.80± | Pink, etc. | **Spessartite** | Sil. | None | G.=4.2.± Insol. | 178 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1.82± | *Red, brown* | **Almandite** | Sil. | None | G.=4.2±. Insol. | 178 |
| 1.89± | Red, brown | **Andradite** | Sil. | None | G.=3.75±. Insol. | 180 |
| 2.13 | **Brown-red** | *Ampangabéite* * | Colum. | ? | Prism. G.=4.2 | 166 |
| 2.15± | Red | *Koppite* | Tant. | ? | Dodec. G.=4.5 | 164 |
| 2.35 Li | **Red** | *Magnesioferrite* | $MgFe_2O_4$ | None | G.=4.6. Oct. | 61 |
| 2.38 | Gray, brown, etc. | Perovskite | $CaTiO_3$ | 100 poor | G.=4. Also biref. | 163 |
| 2.4± | Brown, red | Sphalerite | ZnS | 110 perf. | G.=4.1. Sol. HCl | 19 |
| 2.69 Li | **Red** | *Hauerite* | $MnS_2$ | 100 poor | G.=3.46. Sol. HCl | 24 |
| 2.72 Li | Bright red | Tetrahedrite | Cu, Sb, S | None | G.=5±. Luster! | 26 |
| 2.849 | Cochineal red | Cuprite | $Cu_2O$ | 111 poor | G.=6±. Sol. $H_2SO_4$ | 40 |

## XII. Red Minerals, Not Pleochroic, But Anisotropic

| $N_o$ or $N_m$ | Color | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | (a) Birefringence very weak to moderate: $N_g - N_p < 0.0185$ | | | | | |
| 1.65± | Brown, red | *Hellandite* | Sil. | + | 80° | $X=b$; $Z \wedge c = 44°$ | 425 |
| 1.794 | Blood red | *Arseniopleite* | Arsen. | + | 0° | $10\bar{1}1$ cleav. Sol. HCl | 153 |
| 1.89 | Red, brown | **Andradite** | Sil. | ± | Var. | No cleav. G.=3.75 | 180 |
| 2.38 | Gray, red, etc. | Perovskite | $CaTiO_3$ | + | 90°± | $X=c$. $Y=b$. Poor cleav. | 163 |
| | | (b) Birefringence rather strong to very strong: $N_g - N_p > 0.0185 < 0.0545$ | | | | | |
| 1.508 | (Violet±) Red | *Ussingite* | Sil. | + | 39° | $Z \wedge \perp 001 = 33°\pm$ | 439 |
| 1.8± | Red | *Glockerite* | Sul. | ? | ? | Fibrous | 108 |
| 2.008 | **Red** | Zincite | ZnO | + | 0° | 0001 cleav. G.=5.6 | 41 |

* Usually opaque in sections of standard thickness (.02–.03 mm.); colored in extremely thin sections.

## TABLE III.—COLOR OF MINERALS

### XII. Red Minerals, Not Pleochroic, But Anisotropic—*continued*

| $N_o$ or $N_m$ | Color | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | (c) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.683 | *Pink* | *Koettigite* | Arsen. | + | 77° | X⊥010 cl. $Z \wedge c=37°$ | 127 |
| 1.997 | *Red, brown,* etc. | Cassiterite | $SnO_2$ | + | 0° | Tet. Prism. G.=7± | 52 |
| 2.31 | **Red-purple** | *Geikielite* | $MgTiO_3$ | − | 0° | 10$\bar{1}$1 cleav. G.=3.9 | 67 |
| 2.44 | Yellow-red | *Pyrophanite* | $MnTiO_3$ | − | 0° | 02$\bar{2}$1 cleav. G.=4.5 | 67 |
| 2.58 | Vermilion | *Smithite* | $AgAsS_2$ | − | Mod. | 100 cleav. Y=$b$ | 27 |
| 2.6± | Orange-red | *Hydrohematite* | Ox. | − | 0°? | Fibrous. G.=4.5–5 | 45 |
| 2.6± | Brown-red | **Rutile** * | $TiO_2$ | + | 0° | Tet. Prism. G.=4.2 | 50 |
| 2.65 | Yellowish red | *Lithargite* | PbO | − | 0° | Tet. 110 cleav. G.=9.1 | 41 |
| >2.72 | **Red** | *Lorandite* | $TlAsS_2$ | + | Lg. | Z ‖ 100 and 001 cl. | 28 |
| >2.72 | **Red** | *Miargyrite* * | $AgSbS_2$ | + | Mod. | Poor cleav. G.=5.2 | 27 |
| 2.91 | Bright red | Cinnabar | HgS | + | 0° | 10$\bar{1}$0 cleav. G.=8.2 | 21 |
| 3.0± | Cherry red | *Polybasite* | Ag, Sb, S | − | 22° | X=$c$. Z=$b$. G.=6.1 | 27 |
| 3.084 | **Red** | Pyrargyrite | $Ag_3SbS_3$ | − | 0° | 10$\bar{1}$1 cleav. G.=5.8 | 27 |
| 3.176 | Scarlet | *Hutchinsonite* | Tl, As, S | − | 38° | X=$b$. Y⊥100 cleav. | 28 |
| 3.22 | Blood red | **HEMATITE** * | $Fe_2O_3$ | − | 0° | 0001 part. G.=5.2 | 44 |

### XIII. Red Minerals, Pleochroic in Red

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (a) Birefringence very weak to weak: $N_g-N_p<0.0095$ | | | | | |
| 1.58± | *Pink* | Colorless | Beryl † | Sil. | − | 0° | Hex. Prism. Poor cleav. | 212 |
| 1.59± | *Purple* | Red-purple | *Kaemmererite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 286 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.60± | Colorless | Pink | Delessite | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 282 |
| 1.621 | **Rose-red** | *Pink* | *Gillespite* | Sil. | − | 0° | 0001 cleav. G.=3.33 | 401 |
| 1.72 | *Pink* | Colorless | Vesuvianite | Sil. | − | 0° | Tet. Poor 110 cleav. | 207 |
| 1.77 | Colorless± | Red | *Ruby* | $Al_2O_3$ | − | 0° | 0001 part. H.=9. G.=4 | 43 |
| 1.81± | Colorless± | *Reddish* | *Cerite* † | Sil. | + | 25° | Y=? No cleav. G.=4.9 | 422 |

(b) Birefringence moderate: $N_g - N_p > 0.0095 < 0.0185$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.565 | Colorless | Yel.-red | *Pyroaurite* | Carb. | − | 0° | 0001 cleav. Sol. HCl | 87 |
| 1.62 | *Br.-yellow* | *Violet pink* | Topaz † | Sil. | + | 60°± | Y=*yel.-pink*. Z⊥001 cl. | 198 |
| 1.64 | *Pink* | Colorless | **Andalusite** † | Sil. | − | 84° | Y=Z. X=*c*. Z=*a*. 110 cl. | 201 |
| 1.65 | Colorless | *Pink* | Mullite | Sil. | + | 50° | Y=X. Y⊥010 cl. Z=*c* | 201 |
| 1.725 | *Rose-red* | Colorless | *Roselite* | Arsen. | + | Mod. | X⊥100 cleav.± G.=3.5 | 127 |
| 2.62 | Blood-red: X<Z | | *Arizonite* * | Ox. | ? | Mod. | G.=4.2. Dec. $H_2SO_4$ | 68 |

(c) Birefringence rather strong to strong: $N_g - N_p > 0.0185 < 0.0365$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.57± | Colorless | *Pink* | **Lepidolite** † | Sil. | − | 50° | Y=Z. X⊥001 cleav. | 270 |
| 1.64 | *Red* | **Red** | **BIOTITE** | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 272 |
| 1.73 | Colorless | *Pink* | *Strengite* | Phos. | ± | Sm. | Y=X. Z⊥001 cleav. | 140 |
| 1.735 | Red | *Red* | *Sicklerite* | Phos. | − | Lg. | Y=red. Z⊥cleav. | 158 |
| 1.775 | *Pink* (‖ cl.) to colorless | | *Leucophenicite* | Sil. | − | 74° | X⊥cleav. G.=3.85 | 412 |
| 2.16 | *Pink*: X<Z | | *Bellite* † | Arsen. | − | 0° | Hex. needles. G.=5.5 | 119 |

(d) Birefringence very strong: $N_g - N_p > 0.0365 < 0.0545$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.59± | Purple-red | Purple-red | *Alurgite* | Sil. | − | 0°± | Y=br.-red. X⊥001 cl. | ‡ |
| 1.723 | Colorless | Yel.-red | *Pyrochroite* | $Mn(OH)_2$ | − | 0° | 0001 cleav. Sol. HCl | 42 |
| 1.73 | *Pink* | Colorless± | *Phosphosiderite* † | Phos. | − | 62° | Y=carmine. Y⊥010 cl. | 142 |

* Usually opaque in sections of standard thickness (.02-.03 mm.); colored in extremely thin flakes.
† Usually colorless in sections of standard thickness (.02-.03 mm.); colored in thicker sections.
‡ S. L. Penfield: *Am. Jour. Sci.*, XLVI, 1893, p. 288.

## TABLE III.—COLOR OF MINERALS

### XIII. Red Minerals, Pleochroic in Red—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (d). Birefringence very strong: $N_g-N_p>0.0365<0.0545$—*continued* | | | | | |
| 1.734 | Carmine | Colorless± | *Adamite* | Arsen. | − | 90°± | $X=a$. $Y=c$. G.=4.35 | 133 |
| 1.75 | Br.-red: $X<Y<Z$ | | Iddingsite | Sil. | ± | Var. | $X\perp 100$ cl. $Z\perp 001$ cl. | 437 |
| 1.786 | *Pink*± | Red | *Beraunite* | Phos. | + | Mod. | Y=X. $X\wedge c=89°$. $Z=b$ | 144 |
| 1.9± | **Br.-gray** | Red | *Purpurite* | Phos. | + | 38° | Y=Z. $X\perp 001$ cl. $Z=b$ | 141 |
| | | | (e) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.898 | Colorless± | **Br.-red** | *Mazapilite* | Arsen. | − | 0°± | Y=Z. Orth. Prism. $X=c$ | 156 |
| 2.25 | *Red* | **Red** | *Mangantantalite* | Tant. | + | Lg. | Y=blood red. G.=5 | 165 |
| 2.59 | Orange-red | Vermilion | Realgar | AsS | − | 40° | Y=Z. $X\wedge c=11°$. $Y=b$ | 22 |
| 2.6± | Colorless± | *Red* | *Trechmannite* | $AgAsS_2$ | − | 0° | $10\bar{1}1$, 0001 cleav. | 27 |
| 2.6± | Br.-red | Blood red | **Rutile** * | $TiO_2$ | + | 0° | Tet. Prism. G.=4.2 | 50 |
| >2.72 | Red: $X>Y>Z$ | | *Kermesite* | $Sb_2S_2O$ | + | Sm. | 100, 101 cleav. G.=4.5 | 28 |
| >2.72 | **Deep red** | Opaque± | *Chalcophanite* | Ox. | − | 0° | 0001 cleav. G.=3.91 | 66 |
| 3.0± | Red: $X>Z$ | | Livingstonite | $HgSb_4S_7$ | − | ? | Prism. cleav. $Z=c$ | 28 |
| 3.087 | Red | Blood red | Proustite | $Ag_3AsS_3$ | − | 0° | $10\bar{1}1$ cleav. G.=5.6 | 27 |
| 3.22 | Yel.-red | Br.-red | **HEMATITE** * | $Fe_2O_3$ | − | 0° | Hex. 0001 part. G.=5.2 | 44 |

### XIV. Minerals Pleochroic in Red and Blue

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (a) Birefringence very weak to moderate: $N_g-N_p>0.0185$ | | | | | |
| 1.55± | *Reddish* | *Clear blue* | **Cordierite** † | Sil. | − | 60°± | Y=*violet*. Ps. Hex. twin. | 307 |
| 1.665 | *Purple* | Colorless | *Kunzite* | Sil. | + | 69° | Y=*pink*. $Z\wedge c=25°$ | 236 |
| 1.685 | Blue | Colorless | Dumortierite | Sil. | − | 30°± | Y=red. $Z\perp 100$ cleav. | 422 |
| 1.69 | Red-gray | Gr. blue | *Kataphorite* | Sil. | − | 35°± | Y=br.-red. $Z\wedge c=45°\pm$ | 254 |
| 1.70± | Red | *Blue* | **HYPERSTHENE** | Sil. | − | 70°± | Y=yellow. $X=a$. $Z=c$ | 219 |

(b) Birefringence rather strong to strong: $N_g - N_p > 0.0185 < 0.0365$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.70± | Reddish | Violet | **AUGITE** (Ti) | Sil. | − | 60° | Y=Z. Y=*b*. Z∧*c*=45°± | 228 |
| 1.79± | *Br.-red* | *Gr.-blue* | Tephroite † | Sil. | − | 65° | Y=*red*. X⊥010 cleav. | 194 |
| 1.87± | Br.-red | **Violet** | *Heterosite* | Phos. | − | Lg. | Y=carmine. X⊥001 cl. | 141 |
| 2.146 | Violet red | Violet red | *Rafaelite* | Hal. | ? | ? | Y=**violet.** 001 cleav. | 39 |

(c) Birefringence very strong to extreme: $N_g - N_p > 0.0365$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.663 | *Pinkish* | Red | Erythrite | Arsen. | ± | 90°± | Y=*violet*. X⊥010 cl. | 127 |
| 1.734 | Magenta | Rose | *Adamite* | Arsen. | ± | 83° | Y=purple. X=*a*. Z=*b* | 133 |
| 1.75± | *Greenish* | Pink | **EPIDOTE** ‡ | Sil. | − | 70°± | Y=*blue*. Z∧001 cl.=25° | 314 |
| 1.75± | Yellow | Red | *Piedmontite* | Sil. | + | 70°± | Y=blue. Z∧001 cl.=32° | 315 |

## XV. Minerals Pleochroic in Brown and Blue

(a) Birefringence very weak to moderate: $N_g - N_p < 0.0185$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.685 | *Brown* | *Yellow* | **Axinite** † | Sil. | − | 73° | Y=*violet*. X⊥011± | 425 |
| 1.69± | Red-gray | Gr.-blue | *Kataphorite* | Sil. | − | 35°± | Y=gr.-brown. Z∧*c*=45°± | 254 |
| 1.695 | **Blue** | Brown | **Riebeckite** | Sil. | − | Lg. | Y=blue. X∧*c*=3°±. Z=*b* | 257 |
| 1.72± | *Brown* | Blue | *Sapphirine* † | Sil. | − | 69° | Y=Z. Y=*b*. Z∧*c*=10°± | 427 |
| 1.73± | Br.-green± | Gr.-brown | Chloritoid | Sil. | + | 50°± | Y=**blue.** 001 cleav. | 438 |

(b) Birefringence very strong to extreme: $N_g - N_p > 0.0365$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.60 | **Blue** | *Brownish* | Vivianite | Phos. | + | Lg. | Y=colorless. X⊥010 cl. | 126 |
| 1.762 | Gr.-blue | *Yel.-brown* | *Dihydrite* | Phos. | ± | 90°± | Y=yel.-green. Z ‖ fib.± | 135 |

* Usually opaque in standard sections; colored in extremely thin portions.
† Usually colorless in sections of standard thickness (.02–.03 mm.); colored in thicker sections.
‡ Usually yellowish green to golden in thin section.

TABLE III.—COLOR OF MINERALS

XVI. Blue Minerals, Not Pleochroic and Isotropic

| N | Color | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|---|
| 1.434 | Blue, purple, etc. | Fluorite | $CaF_2$ | 111 perf. | Colored in spots | 31 |
| 1.435 | Violet | *Yttrocerite* | Hal. | 111 perf. | Colored in spots | 36 |
| 1.485± | Yellow, blue, pink | **Sodalite** | Sil. | 110 poor | G.=2.3. Gel. HCl | 289 |
| 1.49± | Blue, yellow, etc. | Noselite | Sil. | 110 poor | G.=2.3. Gel. HCl | 290 |
| 1.50± | Blue | Lazurite | Sil. | 110 poor | G.=2.4. Gel. HCl | 290 |
| 1.54± | Blue-green, blue | *Cornuite* | Sil. | None | G.=2±. Opaline | 413 |
| 1.73± | Red, blue, etc. | Spinel | $MgAl_2O_4$ | 111 poor | H.=8. G.=3.6 | 62 |
| 1.81± | Green, blue, etc. | *Gahnite* | $ZnAl_2O_4$ | 111 fair | G.=4.5. Oct. | 63 |
| 2.05 | Sky-blue | *Percylite* | Hal. | 100 | Sol. $HNO_3$ | 37 |

XVII. Blue Minerals, Not Pleochroic But Anisotropic

| $N_o$ or $N_m$ | Color | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | (a) Birefringence very weak to very strong: $N_g-N_p<0.0545$ | | | | | |
| 1.434 | Blue, purple, etc. | Fluorite * | $CaF_2$ | ? | ? | 111 cleav. G.=3.2 | 31 |
| 1.73± | Gr.-blue | *Connellite* | Sul. | + | 0° | Hex. Acic. G.=3.4 | 118 |
| 1.731 | *Gr.-blue* | *Chalcomenite* | Sel. | − | Var. | Mon. Y=*b*. G.=3.76 | 118 |
| 2.03 | **Blue** | *Pseudoboléite* | Hal. | − | 0° | 001, 101 cleav. G.=4.9 | 37 |
| 2.06 | Gr.-blue | *Boléite* | Hal. | − | 0° | 001, 101 cleav. G.=5 | 37 |
| | | (b) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.658 | *Gr.-blue* | *Veszelyite* | Phos. | + | 71° | No cleav. G.=3.5 | 138 |
| 1.8± | Gr.-blue | *Cornetite* | Phos. | − | 33° | X=*a*. Z=*b*. G.=4.1 | 132 |

XVIII. Blue Minerals Pleochroic in Blue

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| (a) Birefringence very weak to weak: $N_g-N_p<0.0095$ | | | | | | | | |
| 1.58 | *Blue* | *Bluish*± | Beryl † | Sil. | − | 0° | Hex. Prism. G.=2.75± | 212 |
| 1.6± | Colorless | **Blue** | *Aerinite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 285 |
| 1.634 | *Blue*: X>Z or X<Z | | **Apatite †** | Phos. | − | 0° | Hex. Prism. G.=3.2 | 129 |
| 1.66± | Colorless | **Violet** | *Crossite* | Sil. | − | Sm. | Y=blue. X∧c=70°± | 259 |
| 1.71± | Colorless | **Blue** | Vesuvianite † | Sil. | − | 0° | Tet. Poor 110 cleav. | 207 |
| 1.72± | Colorless | **Blue** | ***Sapphirine*** | Sil. | − | 69° | Y=Z. Y=*b*. Z∧c=10°± | 427 |
| 1.769 | *Bluish* | *Blue* | *Sapphire* | $Al_2O_3$ | − | 0° | Hex. H.=9. G.=4± | 43 |
| (b) Birefringence moderate: $N_g-N_p>0.0095<0.0185$ | | | | | | | | |
| 1.555 | Colorless | Colorless | *Vauxite* | Phos. | + | Sm. | Y=blue. Tric. No cl. | 157 |
| 1.665 | Purple | Colorless | *Kunzite* | Sil. | + | 69° | Y=amethystine. Z∧c=25° | 236 |
| 1.685 | **Blue** | Colorless± | Dumortierite | Sil. | − | 30° | Y=Z. X=*c*. Z⊥100 cleav. | 422 |
| 1.722 | Colorless | **Blue** | **Kyanite** | Sil. | − | 82° | Y=blue. 100, 010 cleav. | 205 |
| (c) Birefringence rather strong: $N_g-N_p>0.0185<0.0275$ | | | | | | | | |
| 1.530 | **Blue** | Colorless | ***Minasragrite*** | Sul. | − | Lg. | Y=*blue*. X⊥010 cl. | 110 |
| 1.542 | *Lilac* | Lilac | *Stichtite* | Carb. | − | 0° | 0001 cleav. G.=2.16 | 87 |
| 1.638 | Colorless | **Blue** | Glaucophane | Sil. | − | Mod. | Y=violet. Z∧c=5°± | 258 |
| 1.65± | Colorless | Blue | **Tourmaline** | Sil. | − | 0° | Max. abs.⊥elong. | 301 |
| (d) Birefringence strong: $N_g-N_p>0.0275<0.0365$ | | | | | | | | |
| 1.56 | Colorless | ***Violet*** | **Lepidolite †** | Sil. | − | 50°± | Y=Z. X⊥001 cleav. | 270 |
| 1.632 | Colorless | Blue | Lazulite | Phos. | − | 69° | Inclusions common | 154 |
| 1.73 | Colorless± | **Blue** | *Strengite* | Phos. | ± | Sm. | Y=violet. Z⊥001 cl. | 140 |

* Usually isotropic.

† Usually colorless in standard sections: colored in thicker sections.

## TABLE III.—COLOR OF MINERALS

### XVIII. Blue Minerals Pleochroic in Blue—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (e) Birefringence very strong: $N_g - N_p > 0.0365 < 0.0545$ | | | | | |
| 1.62 | Colorless to *blue* | | *Turquois* | Phos. | + | 40° | Two cleav. G. = 2.84 | 157 |
| 1.722 | Colorless | Blue | Diaspore | AlO(OH) | + | 84° | Y = X. Y ⊥ 010 cleav. Z = *a* | 46 |
| 1.75 | Colorless | Colorless | **EPIDOTE** * | Sil. | − | 70° ± | Y = *blue*. Z ∧ 001 cl. = 25° | 314 |
| 1.757 | Colorless | Blue | *Benitoite* | Sil. | + | 0° | Rhom. Color varies | 212 |
| 1.838 | *Blue* | Prus. blue | *Linarite* | Sul. | − | 80° | Y = blue. X ∧ 100 cl. = 24° | 104 |
| 2.654 | Blue | *Blue* | *Moissanite* | SiC | + | 0° | H. = 9.5. G. = 3.2 | 17 |
| | | | (f) Birefringence extreme: $N_g - N_p > 0.0545$ | | | | | |
| 1.617 | Colorless | Blue | *Kyanotrichite* | Sul. | + | 83° | Y = *blue*. X = *a*. Z = *c* | 116 |
| 1.660 | Colorless | Blue | *Planchéite* | Sil. | + | Mod. | Y = X. X ⊥ cl. Z ‖ fib. | 411 |
| 1.748 | *Gr.-blue* | Gr.-blue | *Freirinite* | Arsen. | − | 0° | 001 cleav. Sol. HCl | 151 |
| 1.758 | Clear blue | **Blue** | Azurite | Carb. | + | 68° | Y = *b*. Z ∧ *c* = −13° | 82 |
| 1.782 | *Blue* | **Blue** | *Shattuckite* | Sil. | + | Lg. | Y = *gr.-blue*. Z ‖ fib. ± | 411 |
| 1.866 | Blue: X and Z > Y | | *Caledonite* | Sul. | − | 85° | X ⊥ 100 cl. Z ⊥ 001 cl. | 120 |
| 2.04 | Clear blue | Blue | *Cumengéite* | Hal. | − | 0° | 101, 110 cleav. G. = 4.8 | 37 |
| 2.55 | Blue | **Blue** | *Octahedrite* | $TiO_2$ | − | 0° | 001, 111 cleav. G. = 3.9 | 53 |

### XIX. Minerals Pleochroic in Blue and Green

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (a) Birefringence very weak or weak: $N_g - N_p < 0.0095$ | | | | | |
| 1.585 | *Bluish* | **Green** | *Metazeunerite* | Arsen. | − | 0° | 001 cleav. G. = 3.28 | 146 |
| 1.624 | *Blue* | Green | *Metatorbernite* | Phos. | + | 0° ± | 001 cleav. G. = 3.7 | 145 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.69± | **Blue** | Green | Arfvedsonite | Sil. | − | Lg. | Y=blue. $X \wedge c$=Sm. | 257 |
| 1.695± | **Indigo** | Green | **Riebeckite** | Sil. | − | Lg. | Y=blue. $X \wedge c=3°±$ | 257 |
| 1.703 | Green | Blue | *Serendibite* | Sil. | + | 90°± | Y=X. No cleav. G.=3.4 | 425 |
| 1.769 | *Green* | *Blue* | *Sapphire* | $Al_2O_3$ | − | 0° | 0001 part. H.=9. G.=4± | 43 |
| | | | (b). Birefringence moderate: $N_g-N_p>0.0095<0.0185$ | | | | | |
| 1.68± | *Yellow±* | *Green±* | **Axinite** | Sil. | − | 75° | Y=blue. X⊥011± | 425 |
| 1.73± | Olive green | *Yellow±* | Chloritoid | Sil. | + | Mod. | Y=blue. 001 cleav. | 438 |
| | | | (c) Birefringence rather strong: $N_g-N_p>0.0185<0.0275$ | | | | | |
| 1.63± | Gr.-yellow | Gr.-blue | **Pargasite** | Sil. | + | 60°± | Y=**green.** $Z \wedge c=25°±$ | 248 |
| 1.655 | *Blue* | *Blue* | ***Euclase*** † | Sil. | + | 50°± | Y=*yel.-green.* Y⊥010 cl. | 432 |
| 1.665 | *Yellow* | *Blue* | **Sillimanite** † | Sil. | + | 27°± | Y=*green.* Y⊥010 cleav. | 200 |
| 1.67± | Yellow | Gr.-blue | **HORNBLENDE** | Sil. | − | 80°± | Y=bl.-green. $Z \wedge c=20°±$ | 247 |
| 1.713 | Green | Blue | *Gerhardtite* | Nit. | + | Lg. | Y=green. Z⊥001 cl. | 89 |
| | | | (d) Birefringence very strong: $N_g-N_p>0.365<0.0545$ | | | | | |
| 1.60± | **Blue** | *Olive green* | Vivianite | Phos. | + | Lg. | Y=colorless. X⊥010 cl. | 126 |
| 1.75± | Greenish | Pink | **EPIDOTE** * | Sil. | − | 70°± | Y=blue. $X \wedge 001$ cl.=25° | 314 |
| 2.654 | Olive green | Gr.-blue | *Moissanite* | SiC | + | 0° | Poor 0001 cleav. H.=9.5 | 17 |
| | | | (e) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.642 | *Green* | **Gr.-blue** | *Serpierite* | Sul. | − | 35° | Y=Z. X⊥001 cleav. | 102 |
| 1.668 | Blue | Yel.-green | *Symplesite* | Arsen. | − | 87° | Y=yellow. X⊥010 cl. | 126 |
| 1.745 | *Bluish* | *Bluish* | *Libethenite* | Phos. | − | 83° | Y=yel.-green. X=*b*. Z=*a* | 132 |
| 1.762 | Gr.-blue | *Yel.-brown* | *Dihydrite* | Phos. | ± | 90°± | Y=yel.-green. Z=*b*± | 135 |

* Usually yellowish green to golden in thin section.
† Usually colorless in standard sections: colored in thicker sections.

## TABLE III.—COLOR OF MINERALS

### XX. Green Minerals, Not Pleochroic and Isotropic

| N | Color | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|---|
| 1.434 | Red, green, etc. | Fluorite * | $CaF_2$ | 111 perf. | G. = 3.18. Cubic | 31 |
| 1.50± | Blue, green, etc. | Hauynite | Sil. | 110 poor | G. = 2.4. Gel. HCl | 290 |
| 1.54± | Green, blue, etc. | *Cornuite* | Sil. | None | G. = 2±. Sol. HCl | 413 |
| 1.585 | Green | *Volchonskoite* | Sil. | None | G. = 2.3. Gel. HCl | 416 |
| 1.59± | **Emerald green** | *Zaratite* | Carb. | None | G. = 2.6. Sol. HCl | 85 |
| 1.59 | Bright green | *Garnierite* | Sil. | None | Fibrous. Dec. HCl | 261 |
| 1.60± | Oil-green | *Voltaite* | Sul. | ? | G. = 2.79. Sol. $H_2O$ | 115 |
| 1.65 | Green, brown, etc. | *Greenalite* † | Sil. | None | G. = 2.8+. Sol. HCl | 413 |
| 1.725 | *Green* | *Rowlandite* | Sil. | None | G. = 4.5. Gel. HCl | 420 |
| 1.758 | *Green* | *Yttrialite* | Sil. | None | G. = 4.58. Sol. HCl | 414 |
| 1.77± | Green | *Ceylonite* | $MgAl_2O_4$ | 111 poor | G. = 3.6. Oct. | 62 |
| 1.77± | Grass-green | *Chlorospinel* | $MgAl_2O_4$ | 111 poor | G. = 3.6. Oct. | 62 |
| 1.8± | Green, blue, etc. | *Gahnite* | $ZnAl_2O_4$ | 111 fair | G. 4.5. Oct. | 63 |
| 1.87± | Green | *Uvarovite* | Sil. | None | G. = 3.7±. Insol. | 263 |
| 1.9± | Green | *Hercynite* | $FeAl_2O_4$ | ? | G. = 3.9. Insol. | 62 |
| 2.16 Li | **Emerald green** | *Manganosite* | MnO | 100 | G. = 5.18. Oct. | 41 |
| 2.23 | Green, brown | *Bunsenite* | NiO | ? | G. = 6.4. Oct. | 41 |

### XXI. Green Minerals, Not Pleochroic, But Anisotropic

| $N_o$ or $N_m$ | Color | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|
| | | (a) Birefringence very weak to weak: $N_g - N_p < 0.0095$ | | | | | |
| 1.483 | *Blue-green* | *Zn-Cu-melanterite* | Sul. | + | Lg. | Y ∧ fib. = Lg. Z = *b* | 106 |
| 1.556 | *Blue-green* | *Miloschite* | Sil. | − | 90°± | 001 cleav. G. = 2.1 | 416 |
| 1.69 | *Green* | *Pharmacosiderite* | Phos. | − | Sm. | Cubic. G. = 3 | 143 |

(b) Birefringence rather strong to very strong: $N_g - N_p > 0.0185 < 0.0545$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.59 | Yellow-green | *Connarite* | Sil. | − | 0°± | X⊥001 cl. G. = 2.5 | 280 |
| 1.686 | *Blue-green* | *Trichalcite* | Arsen. | − | Lg. | X⊥plates. Sol. HCl | 124 |
| 1.698 | Bluish green | *Euchroite* | Arsen. | + | 29° | X = *b*. Z ∥ prism. | 136 |
| 1.77 | *Green* | *Conichalcite* | Arsen. | − | 25° | X = *c*. Z ∥ *a* = fib. | 136 |
| 1.774 | Yellow-green | *Barthite* | Arsen. | + | Mod. | No cleav. G. = 4.19 | 160 |
| 2.01 | *Green* | *Volborthite* | Van. | ± | Var. | Bx.⊥cleav. G. = 3.5 | 137 |
| 2.05 | Dull green | *Fernandinite* | Van. | ? | ? | Fibrous. Sol. HCl | 148 |
| 2.15 | Green | *Cuprotungstite* | Tung. | ? | ? | One cleav. G. = 3.95 | 105 |

(c) Birefringence extreme: $N_g - N_p > 0.0545$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.652 | Greenish | *Liroconite* | Arsen. | − | 67° | X = *b*. Z∧*c* = −25° | 157 |
| 1.70 | *Green* | *Ancylite* | Carb. | − | 66° | No cleav. G. = 3.95 | 87 |
| 1.745 | *Green* | *Libethenite* | Phos. | − | 83° | X = *b*. Z = *a*. Poor cl. | 132 |
| 1.745 | *Green* | *Mixite* | Arsen. | + | Sm. | Z ∥ fib. G. = 3.8 | 156 |
| 1.90 | Bluish green | *Trippkeite* | Arsen. | + | 0° | 100 cleav. Sol. HCl | 159 |

## XXII. Green Minerals Pleochroic in Green

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (a) Birefringence very weak: $N_g - N_p < 0.0035$ | | | | | |
| 1.57± | Colorless | *Green* | **Penninite** | Sil. | − | Sm. | Y = Z. X⊥001 cl. G. = 2.7± | 281 |
| 1.59± | *Green* | Colorless | **Penninite** | Sil. | + | Sm. | Y = X. Z⊥001 cl. G. = 2.8± | 281 |
| 1.60± | Colorless | *Green* | Delessite | Sil. | − | Sm. | Y = Z. X⊥001 cl. G. = 2.8± | 282 |
| 1.62± | Colorless | *Green* | Diabantite | Sil. | − | Sm. | Y = Z. X⊥001 cl. G. = 2.8± | 283 |

* Usually colorless or purple in standard sections; may be colored red or green in thicker sections.
† Often opaque in standard sections; colored in extremely thin portions.

## TABLE III.—COLOR OF MINERALS

### XII. Green Minerals Pleochroic in Green—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (a) Birefringence very weak: $N_g-N_p<0.0035$—*continued* | | | | | |
| 1.62± | *Green* | Colorless± | Ripidolite | Sil. | + | Sm. | Y=X. Z⊥001 cl. G.=2.9± | 284 |
| 1.64± | Colorless± | Green | Aphrosiderite | Sil. | − | Sm. | Y=Z. X⊥001 cl. G.=2.96 | 284 |
| 1.66± | Colorless± | Green | Daphnite | Sil. | − | Sm. | Y=Z. X⊥001 cl. G.=3.0 | 285 |
| | | | (b). Birefringence weak: $N_g-N_p>0.0035<0.0095$ | | | | | |
| 1.58± | *Green* | *Yel.-green* | Beryl * | Sil. | − | 0° | Hex. Prism. G.=2.75± | 212 |
| 1.58± | *Green* | Colorless± | **Clinochlore** | Sil. | + | Sm. | Y=X. Z⊥001 cl. G.=2.7± | 283 |
| 1.60± | *Green* | Colorless± | Prochlorite | Sil. | + | Sm. | Y=X. Z⊥001 cl. G.=3.07 | 284 |
| 1.66± | Colorless± | Green | Thuringite | Sil. | − | Sm. | Y=Z. X⊥001 cl. G.=3.07 | 285 |
| **1.69±** | **Bl.-green** | Br.-green | Arfvedsonite | **Sil.** | **−** | **Lg.** | Y=X. X∧c=Sm. Z=*b* | 257 |
| 2.33 | Gray-green: X<Z | | *Dysanalite* † | Tit. | + | 90°± | Y=? Y=*c*. Z=*b*. G.=4.1 | 163 |
| | | | (c) Birefringence moderate: $N_g-N_p>0.0095<0.0185$ | | | | | |
| 1.55± | Colorless | *Green* | **Chrysotile** | Sil. | + | 30° | Y=X. Z ∥ fib. G.=2.5 | 260 |
| 1.59± | **Bl.-green** | *Br.-green* | Corundophilite | Sil. | + | Sm. | Y=X. Z⊥001 cl.± G.=2.9± | 283 |
| 1.6± | *Green* | Colorless | Chrysocolla | Sil. | ± | Sm. | Fibrous. G.=2.4± | 411 |
| 1.63± | *Yel.-green* | **Green** | Celadonite | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 436 |
| 1.64± | Colorless± | *Green* | *Chamosite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 286 |
| 1.662 | Olive green: X>Y>Z | | *Dickinsonite* | Phos. | + | Mod. | X=*b*. Y⊥001 cleav.± | 122 |
| 1.671 | Green | Colorless | *Hiddenite* | Sil. | + | 56° | Y=greenish. Z∧c=27° | 236 |
| 1.69± | Green | Colorless | Dumortierite | Sil. | − | 30° | Y=X. Z⊥100 cleav. | 422 |
| 1.700 | Colorless | Colorless | *Pumpellyite* | Sil. | + | Lg. | Y=green. X⊥001 cl. | 432 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.701 | *Yel.-green* | Colorless | *Tinzenite* | Sil. | − | 63° | Y=*greenish*. X⊥100 cl.± | 428 |
| 1.73± | *Greenish* | *Green* | **Clinozoisite** | Sil. | + | 85°± | Y=X. Z∧001 cl.=20°± | 312 |
| 1.74± | *Green* | **Green** | **Hedenbergite** | Sil. | + | 60° | Y=yel.-green. Z∧*c*=48° | 224 |
| 1.78 | Olive green | Green | *Gadolinite* | Sil. | + | 85° | Y=Z. Y=*b*. X∧*c*=10°± | 424 |
| 1.84 | Yel.-green: X<Z | | *Dussertite* | Arsen. | − | 0° | Hex. Lam. G.=3.75. Sol. HCl | 153 |
| | | | (d) Birefringence rather strong: $N_g-N_p>0.0185<0.0275$ | | | | | |
| 1.594 | Colorless | Green | *Astrolite* | Sil. | − | 30° | Y=Z. X⊥cleav. G.=2.8 | 429 |
| 1.61± | Yel.-green | Olive green | *Nontronite* | Sil. | − | Var. | Y=X. X⊥001 cleav. | 415 |
| 1.63± | Yel.-green: X<Y=Z | | Glauconite † | Sil. | − | Sm. | X⊥001 cleav. G.=2.5± | 436 |
| 1.643 | *Green:* X<Z | | *Zeunerite* | Arsen. | − | 0°± | X⊥001 cleav. G.=3.2 | 146 |
| 1.646 | Colorless | *Green* | **Tourmaline** | Sil. | − | 0° | Max. abs.⊥elong. | 301 |
| 1.67± | Yel.-green | **Green** | **HORNBLENDE** | Sil. | − | 80°± | Y=olive. X∧*c*=20°± | 247 |
| 1.67± | *Green* | Opaque± | *Strigovite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 437 |
| 1.68± | Colorless | Gray-green | *Sincosite* | Phos. | − | 0° | X⊥001 cleav. G.=2.8 | 147 |
| 1.786 | *Sea green* | Yel.-green | *[illegible] actue* | Arsen. | − | Sm. | Y=Z. X∧*c*=50°. G.=3.8 | 155 |
| | | | (e) Birefringence strong: $N_g-N_p>0.0275<0.0365$ | | | | | |
| 1.558 | Colorless | *Green* | *Metavariscite* | Phos. | + | 55° | Y=Z. X=*a* (elong.). Y=*b* | 141 |
| 1.62± | Green | Yel.-green | *Nepouite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 279 |
| 1.726 | Grass green | Grass green | *Tyrolite* | Arsen. | − | 36° | Y=yel.-green. X⊥001 cl. | 161 |
| 1.77± | Colorless | *Bl.-green* | *Conichalcite* | Arsen. | ± | 25° | Y=*greenish*. Z ∥ fib. | 136 |
| 1.78± | Colorless | *Green* | **Allanite** | Sil. | − | Lg. | Y=? G.=4.1. Gel. HCl | 316 |
| 1.78± | Colorless | Green | Scorodite ‡ | Arsen. | + | 62° | Y=? X=*b*. Z=*c*. G.=3.2 | 139 |
| | | | (f) Birefringence very strong: $N_g-N_p>0.0365<0.0545$ | | | | | |
| 1.595 | Colorless | **Bl.-green** | *Fuchsite* | Sil. | − | 40°± | Y=yel.-green. X⊥001 cl. | 269 |
| 1.636 | **Bl.-green** | **Green** | *Grandidierite* | Sil. | − | 30° | Y=colorless. X⊥100 cl. | 421 |

* Usually colorless in standard sections; colored in thicker sections.

† Usually opaque in standard sections; may be colored in extremely thin portions.

‡ Pleochroic colors transposed on page 138.

TABLE III.—COLOR OF MINERALS

XXII. Green Minerals Pleochroic in Green—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (f) Birefringence very strong: $N_g-N_p>0.0365<0.0545$—*continued* | | | | | |
| 1.657 | *Green*: X>Z | | *Dioptase* * | Sil. | + | 0° | $10\bar{1}1$ cleav. Gel. HCl | 186 |
| 1.694 | Bl. green | Green | *Spangolite* | Sul. | − | 0° | 0001 cleav. G.=3.14 | 119 |
| 1.697 | Colorless | *Greenish* | **Grunerite** | Sil. | − | 80° | Y=X. Y=*b*. $Z \wedge c=12°\pm$ | 242 |
| 1.80± | **Green** | Opaque± | Cronstedtite | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 285 |
| 1.831 | Green | Bl.-green | *Higginsite* | Arsen. | − | 90°± | Y=yel.-green. X=*a*. Y=*b* | 132 |
| 1.86 | *Green* | Grass green | *Atacamite* | Hal. | − | 75° | Y=yel.-green. X⊥010 cl. | 38 |
| | | | (g) Birefringence extreme: $N_g-N_p>0.0565$ | | | | | |
| 1.618 | *Green* | Bl.-green | *Chalcophyllite* | Arsen. | − | 0° | 0001 cleav. G.=2.5 | 136 |
| 1.649 | *Green* | Bl.-green | *Herrengrundite* | Sul. | − | 39° | Y=green. X⊥001 cl.± | 104 |
| 1.67± | Colorless | *Green* | *Ekmannite* | Sil. | − | Sm. | Y=Z. X⊥001 cl. G.=2.79 | 281 |
| 1.737 | *Yel.-green* | Green | *Antlerite* | Sul. | − | 35° | Y=Z. X⊥010 cl. G.=3.9 | 102 |
| 1.74± | Colorless± | *Green* | *Aurichalcite* | Carb. | − | Sm. | Y=Z. Y⊥100 cleav.± | 84 |
| 1.745 | *Green* | *Green* | *Libethenite* | Phos. | − | 83° | Y=green. X=*b*. Y=*c* | 132 |
| 1.760 | Bl.-green | **Bl.-green** | *Langite* | Sul. | − | 81° | Y=yel.-green. X⊥001 cl. | 102 |
| 1.778 | Green: X and Y<Z | | *Brochantite* | Sul. | − | 72° | X⊥010 cleav. Z=*c* | 102 |
| 1.840 | Colorless | *Green* | *Chalcosiderite* | Phos. | − | 24° | Y=? X⊥010 cleav.± | 157 |
| 1.87 | *Bl.-green* | Benzol green | *Clinoclasite* | Arsen. | − | 53° | Y=bl.-green. X⊥001 cl.± | 135 |
| 1.875 | Colorless± | **Green** | Malachite | Carb. | − | 43° | Y=yel.-green. $X \wedge c=23°$ | 85 |
| 2.2± | Yel.-green | Grass-green | Huebnerite | Tung. | + | Lg. | Y=*green*. X⊥010 cl. | 101 |

XXIII. Minerals Pleochroic in Green and Yellow

(a) Birefringence very weak to weak: $N_g-N_p<0.0095$

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.57± | *Yellow* | *Green* | **Antigorite** | Sil. | − | Sm. | Y=Z. X⊥001 cl. G.=2.6± | 280 |
| 1.60± | *Yellow* | Green | Delessite | Sil. | − | Sm. | Y=Z. X⊥001 cl. G.=2.8± | 282 |
| 1.60± | Green | *Gr.-yellow* | Prochlorite | Sil. | + | Sm. | Y=X. Z⊥001 cl. G.=2.85 | 284 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.655 | *Yel.-green* | *Gr.-yellow* | *Uranochalcite* | Sul. | + | Sm. | Y=X. Z ‖ fib. Sol. HCl | 117 |
| 1.66± | *Yellow* | Green | Daphnite | Sil. | − | Sm. | Y=Z. X⊥001 cl. G.=3.0 | 381 |
| 1.695 | **Blue** | Green | Riebeckite | Sil. | − | Lg. | Y=gr.-yellow. X∧*c*=3° | 257 |
| 1.72± | *Green* | *Gr.-yellow* | Vesuvianite * | Sil. | − | 0° | Tet. G.=3.4. Contacts | 207 |
| | | | (b) Birefringence moderate: $N_g - N_p > 0.0095 < 0.0185$ | | | | | |
| 1.545 | *Gr.-yellow* | *Green* | **Chrysotile** * | Sil. | + | 30° | Y=Z. Z ‖ fib. G.=2.4 | 260 |
| 1.592 | *Green* | *Gr.-yellow* | *Torbernite* | Phos. | − | 0°± | X⊥001 cleav. G.=3.2 | 145 |
| 1.64± | *Yellow* | *Gr.-yellow* | **Andalusite** * | Sil. | − | 84° | Y=green. X ‖ 110 cleav. | 201 |
| 1.660 | Orange | *Green* | *Brandisite* | Sil. | − | 57° | Y=Z. X⊥001 cl. G.=3.1 | 286 |
| 1.675 | *Red-yellow* | *Green* | *Kornerupine* * | Sil. | − | 20° | Y=*yellow*. X ‖ 110 cl. | 421 |
| 1.681 | *Yellow* | *Greenish* | *Prismatine* * | Sil. | − | 30° | Y=*br.-yellow*. X=*c* | 421 |
| 1.685 | *Yellow* | *Green* | **Axinite** | Sil. | − | 75° | Y=*blue*. X⊥011± | 425 |
| 1.70± | Red-yellow | Green | **HYPERSTHENE** | Sil. | − | 70°± | Y=yellow. X=*a*. Z=*c* | 219 |
| 1.72± | Olive green | *Yellow* | Chloritoid | Sil. | + | 50°± | Y=**blue**. 001 cleav. | 438 |
| 2.061 | *Yellow* | *Green* | Pyromorphite | Phos. | − | 0° | Hex. Prism. G.=7.0 | 131 |
| | | | (c) Birefringence rather strong: $N_g - N_p > 0.0185 < 0.0275$ | | | | | |
| 1.547 | **Bl.-green** | *Yellow±* | *Voglite* | Carb. | + | 60° | Y=X. X nearly ⊥ scales | 88 |
| 1.6± | Gr.-yellow | Green | Bowlingite | Sil. | − | Sm. | Y=Z. X⊥001 cleav.± | 437 |
| 1.62± | *Yellow* | Green | *Nontronite* | Sil. | − | Var. | Y=olive. X⊥001 cl. | 415 |
| 1.63± | Gr.-yellow | Gr.-blue | **Pargasite** | Sil. | + | 60° | Y=**green**. X∧*c*=25°± | 248 |
| 1.63± | *Yellow* | Green | Actinolite | Sil. | − | 80° | Y=gr.-yellow. Z∧*c*=15°± | 245 |
| 1.63± | *Yellow* | Green | Glauconite † | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 436 |
| 1.66± | *Yellow* | *Blue* | **Sillimanite** * | Sil. | + | 30° | Y=*green*. Y⊥010 cl. | 200 |
| 1.67± | *Yellow* | **Blue, green** | **HORNBLENDE** | Sil. | − | 80° | Y=green, yellow. 110 cl. | 247 |
| 1.680 | Colorless± | Green | *Sincosite* | Phos. | − | 0°± | X⊥001 cleav. G.=2.8 | 147 |
| 1.725 | *Bl.-green* | *Br.-yellow* | *Homilite* * | Sil. | + | 80° | Y=*br.-gray*. Y=*c*± | 424 |
| 1.786 | *Sea green* | *Yellow* | *Allactite* | Arsen | − | Sm. | Y=Z. X∧*c*=50°±. G.=3.8 | 155 |

* Usually colorless in standard sections; colored in thicker sections.

† Usually opaque in standard sections; may be colored in extremely thin portions.

TABLE III.—COLOR OF MINERALS

XXIII. MINERALS PLEOCHROIC IN GREEN AND YELLOW—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (d) Birefringence strong: $N_g-N_p>0.0275<0.0365$ | | | | | |
| 1.619 | *Br.-yellow* | *Yel.-green* | Chondrodite | Sil. | + | Lg. | Y=Z. $X\wedge a=28°\pm$ | 196 |
| 1.670 | *Br.-yellow* | *Yel.-green* | Clinohumite | Sil. | + | 76° | Y=Z. $X\wedge a=10°\pm$ | 197 |
| 1.671 | Yellow | **Yellow** | *Manganandalusite* | Sil. | + | 71° | Y=green. 110 cleav. $X=a$ | 202 |
| 1.69± | Green | *Yellow* | Aegirinaugite | Sil. | + | 65° | Y=gr.-yellow. $Z\wedge c=70°\pm$ | 232 |
| 1.77± | *Yellowish* | *Bl.-green* | *Conichalcite* | Arsen. | −? | 25° | Y=*greenish*. Z ∥ fib. | 136 |
| 1.78± | *Yellow* | *Green* | Scorodite | Arsen. | + | 62° | Y=? $X=b$. $Y=a$. G.=3.2 | 139 |
| 1.85 | Gr.-yellow | Pink | *Törnebohmite* | Sil. | + | 26° | Y=bl.-green. G.=4.9 | 414 |
| 1.9± | Br.-yellow | **Green** | Ilvaite | Sil. | − | Sm. | Y=**brown**. $Z=c$ | 431 |
| | | | (e) Birefringence very strong: $N_g-N_p>0.0365<0.0545$ | | | | | |
| 1.63± | Yellow | **Green** | **BIOTITE** | Sil. | − | 0°± | Y=Z. X⊥001 cleav. | 272 |
| 1.687 | Yellow | **Green** | **Tourmaline** | Sil. | − | 0° | Max. abs.⊥elong. | 301 |
| 1.70± | *Yellow* | **Blue, green** | **HORNBLENDE** | Sil. | − | 80° | Y=green, yellow. 110 cl. | 247 |
| 1.75± | *Yellow* | Yel.-green | **EPIDOTE** | Sil. | − | 70°± | Y=golden. $Z\wedge 001$ cl.=25° | 314 |
| 1.793 | Green | *Yellow* | *Thortveitite* | Sil. | − | 66° | Y=Z. $X\wedge c=+5°$. G.=3.5 | 211 |
| 1.80 | Green | *Yellow* | **Acmite** | Sil. | − | 60° | Y=yel.-green. 110 cl. | 234 |
| 1.845 | *Yellow* | **Green** | *Kraurite* | Phos. | + | Sm. | Y=Z. $X=a$. $Y=c$ | 142 |
| | | | (f) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.54± | Yel.-green | Yellow | *Copiapite* | Sul. | + | 60°± | Y=*yellow*. X⊥001 cl. | 108 |
| 1.561 | *Yel.-green* | Yellow | Humboldtite | Oxal. | + | Lg. | Y=*gr. yellow*. $X=a$. $Z=c$ | 88 |
| 1.569 | Yellow | Br.-green | *Griffithite* | Sil. | − | Sm. | Y=olive. X⊥001 cl. | 434 |
| 1.668 | Bl.-green | *Yellowish* | *Symplesite* | Arsen. | − | 87° | Y=colorless. X⊥010 cl. | 126 |
| 1.69± | *Yellowish* | **Br.-green** | *Stilpnomelane* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 435 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.745 | *Yellow* | *Yellow* | *Libethenite* | Phos. | − | 83° | Y = yel-green. X = *b*. Y = *c* | 132 |
| 1.810 | *Greenish* | *Yellow* | *Olivenite* | Arsen. | + | 82° | Y = X. X = *a*. Y = *c* | 132 |
| 1.840 | Golden | Green | *Dufrenite* | Phos. | ± | 90° ± | Y = br.-yellow. Z ⊥ 010 cl. | 142 |

## XXIV. Minerals Pleochroic in Green and Brown

(a) Birefringence very weak to moderate: $N_g - N_p < 0.0185$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.55 ± | *Green* | *Clear brown* | **Cordierite** * | Sil. | − | 60° ± | Y = green. Ps. Hex. twin. | 307 |
| 1.60 ± | Yel.-green | *Brownish* | Prochlorite | Sil. | + | Sm. | Y = X. Z ⊥ 001 cleav. G. = 2.8 | 284 |
| 1.66 ± | Red-brown | Green | *Xanthophyllite* | Sil. | − | Sm. | Y = Z. X ⊥ 001 cl. G. = 3.1 | 286 |
| 1.69 ± | **Green** | Gr.-brown | Arfvedsonite | Sil. | − | Lg. | Y = yel.-brown. X ∧ *c* = Sm. | 257 |
| 1.70 ± | Red | Green | **HYPERSTHENE** | Sil. | − | 70° ± | Y = yel.-brown. X = *a*. Z = *c* | 219 |
| 1.73 ± | Br.-green | *Gr.-brown* | Chloritoid | Sil. | + | Mod. | Y = **blue**. 001 cleav. | 438 |

(b) Birefringence rather strong: $N_g - N_p > 0.0185 < 0.0275$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.625 | Olive green | Brown | *Roscherite* | Phos. | − | Lg. | Y = yel.-brown. Y ∧ *c* = 15° | 156 |
| 1.64 ± | *Brown* | *Green* | **Anthophyllite** * | Sil. | + | Lg. | Y = X. X = *a*. Z = *c*. 110 cl. | 240 |
| 1.67 ± | *Brownish* | Green | **HORNBLENDE** | Sil. | − | 80° ± | Y = *brown, green*. 110 cl. | 247 |
| 1.68 ± | *Greenish* | *Greenish* | Diallage * | Sil. | + | 60° | Y = *brownish*. 100 part. | 228 |
| 1.70 ± | *Greenish* | *Greenish* | **AUGITE** * | Sil. | + | 60° | Y = *brownish*. Z ∧ *c* = 45° ± | 228 |

(c). Birefringence strong: $N_g - N_p > 0.0275 < 0.0365$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.66 ± | *Brownish* | **Green** | **Tourmaline** | Sil. | − | 0° | Max. abs. ⊥ elong. | 301 |
| 1.70 ± | Green | Brownish | Aegirinaugite | Sil. | + | 65° ± | Y = X. Z ∧ *c* = 70° ±. 110 cl. | 232 |
| 1.726 | **Green** | Brown | Babingtonite | Sil. | + | 60° | Y = *brown*. 110 cl. | 428 |
| 1.80 ± | **Red-brown** | Olive green | Cronstedtite | Sil. | − | 0° ± | Y = Z. X ⊥ 001 cleav. | 285 |
| 1.89 ± | Brown | **Green** | Ilvaite | Sil. | − | Sm. | Y = **brown**. Z ⊥ 001 cleav. | 431 |

* Often colorless in standard sections: colored in thicker sections.

# TABLE III.—COLOR OF MINERALS

## XXIV. MINERALS PLEOCHROIC IN GREEN AND BROWN—*continued*

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (d) Birefringence very strong: $N_g-N_p>0.0365<0.0545$ | | | | | |
| 1.70± | Colorless | *Greenish* | Grunerite * | Sil. | − | 82° | Y=*brown*. $Z\wedge c=12°\pm$ | 242 |
| 1.75± | Green | Green, yellow | **EPIDOTE †** | Sil. | − | 70°± | Y=brown. $Z\wedge 001$ cl.=25° | 314 |
| 1.77± | **Brown** | Br.-green | **Acmite** | Sil. | − | 66° | Y=Z. $X\wedge c=5°$. $Y=b$ | 234 |
| 1.801 | Yel.-green | Or.-brown | *Flinkite* | Arsen. | + | Lg. | Y=X. No cleav. $Y=c$. $Z=a$ | 154 |
| | | | (e) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.625 | *Brown* | *Green* | *Bisbeeite* * | Sil. | + | Sm. | Y=X. X⊥laths | 411 |
| 1.685 | Olive green | **Gr.-brown** | *Roscoelite* | Sil. | − | Sm. | Y=X. X⊥001 cleav. | 270 |
| 1.762 | Gr.-blue | *Yel.-brown* | *Dihydrite* | Phos. | ± | 90°± | Y=yel.-green. $X\wedge c=22°$ | 135 |
| 1.84 | **Red-brown** | Green | *Dufrenite* | Phos. | ± | 90°± | Y=*yellow*. Z⊥010 cl. | 142 |
| 1.85± | Green | Red-brown | *Ludwigite* | Bor. | + | Sm. | Y=X. Z ‖ fib. G.=4 | 94 |
| 2.19 | Red-brown | Red-brown | *Baddeleyite** | $ZrO_2$ | − | 30° | Y=oil green. $X\wedge c=12°$ | 60 |
| 2.22 | *Green* | *Brown* | *Vauquelinite* | Chrom. | − | 0°± | Y=Z. No cleav. X ‖ fib. | 121 |
| 2.50 | **Brown** | **Green** | *Strueverite* | Tit. | −? | 0° | Tet. Prism. G.=5.56 | 164 |
| ? | (*a*=) Yel.-brown | **Green** | *Chloroxiphite* | Hal. | − | ? | X⊥001 cleav.±. G.=6.8 | 39 |

## XXV. MINERALS PLEOCHROIC IN GREEN AND RED

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (a) Birefringence very weak to rather strong: $N_g-N_p<0.0275$ | | | | | |
| 1.64± | Red | Olive green | **Andalusite** * | Sil. | − | 85° | Y=green. $X=c$. $Z=a$. 110 cl. | 201 |
| 1.70± | Red | Green | **HYPERSTHENE** * | Sil. | − | 75°± | Y=brown. $X=a$. $Z=c$ | 219 |
| 1.71± | *Yel.-green* | *Greenish* | **Pigeonite** * | Sil. | + | Sm. | Y=*pink*. $Z\wedge c=35°\pm$ | 222 |
| 1.725 | Green | Smoky | *Homilite* * | Sil. | + | 80° | Y=**red**. $Y\wedge c=-1°$. $X=b$ | 424 |
| 1.73± | *Green* | *Red* | **Clinozoisite** * | Sil. | + | 80°± | Y=*pink*. $Z\wedge 001$ cl.=20°± | 312 |
| | | | (b) Birefringence strong to very strong: $N_g-N_p>0.0275<0.0545$ | | | | | |
| 1.57± | *Yellow* | Br.-red | **Phlogopite** * | Sil. | − | Sm. | Y=br.-green. X⊥001 cl. | 272 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.58± | Green | Br.-red | *Cryophyllite* | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 271 |
| 1.726 | **Bl.-green** | **Green** | Babingtonite | Sil. | + | 62° | Y=*claret*. 110 cleav. | 428 |
| 1.75± | *Greenish* | Pink | **EPIDOTE** | Sil. | − | 70°± | Y=yellow. Z∧001 cl.=25°± | 314 |
| 1.78± | *Pink* | *Green* | Scorodite | Arsen. | + | 62° | Y=? X=*b*. Z=*c*. G.=3.2 | 139 |
| 1.85± | Pink | Pink | *Törnebohmite* | Sil. | + | 26° | Y=bl.-green. G.=4.9 | 414 |
| | | | (c) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.997 | *Red* | *Green* | Cassiterite * | $SnO_2$ | + | 0° | Tet. Prism. G.=7± | 52 |
| 1.997 | *Yel.-green* | *Reddish* | Cassiterite * | $SnO_2$ | + | 0° | Tet. Prism. G.=7± | 52 |
| 2.61 | *Red* | *Green* | **Rutile** ‡ | $TiO_2$ | + | 0° | Tet. Prism. G.=4.2 | 50 |
| | | | XXVI. GRAY MINERALS | | | | | |
| | | | (a) Birefringence very weak or weak: $N_g-N_p<0.0095$ | | | | | |
| 1.64± | *Gray*, etc.: X<Z (or X>Z) | | **Apatite** * | Phos. | − | 0° | Hex. Prism. G.=3.2 | 129 |
| 1.72± | *Br.-gray* | *Yel.-green* | Vesuvianite * | Sil. | ± | 0° | Tet. Poor cl. G.=3.4 | 207 |
| 2.38 | Gray | Gray | Perovskite | $CaTiO_3$ | + | 90°± | Cubic. Poor cleav. G.=4 | 163 |
| | | | (b) Birefringence moderate or rather strong: $N_g-N_p>0.0095<0.0275$ | | | | | |
| 1.725 | Bl.-green | Smoky gray | *Homilite* * | Sil. | + | 80° | Y=**brownish gray.** Y∧*c*=1° | 424 |
| 2.38 | Gray | Gray | Perovskite | $CaTiO_3$ | + | 90°± | Cubic. Poor cleav. G.=4 | 163 |
| | | | (c) Birefringence strong or very strong: $N_g-N_p>0.0275<0.0545$ | | | | | |
| 1.57± | *Yellowish* | Br.-gray | **Zinnwaldite** | Sil. | − | Sm. | Y=Z. X⊥001 cleav. | 270 |
| 1.86± | **Br.-gray** | Purple | *Purpurite* | Phos. | + | 38° | Y=scarlet. X=*c*. Z=*b* | 141 |
| 1.95± | Gray: X<Z | | **Zircon** * | $ZrSiO_4$ | + | 0° | Tet. Prism. G.=4.7 | 183 |
| | | | (d) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.87± | Colorless | Ash gray | **Siderite** | $FeCO_3$ | − | 0° | 10$\bar{1}$1 cleav. G.=3.89 | 76 |
| 1.95± | Gray: X<Z | | **Zircon** * | $ZrSiO_4$ | + | 0° | Tet.Prism. G.=4.7 | 183 |

* Often colorless in standard sections; colored in thicker sections.

† Usually pleochroic in golden yellow in standard sections; may be colored as above in thicker sections.

‡ Often opaque in standard sections; colored in extremely thin portions.

# SUPPLEMENTARY TABLE III.—COLOR OF MINERALS

## I. Minerals Pleochroic in Yellow and Blue

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | (d) Birefringence strong to extreme: $N_g-N_p>0.0275$ | | | | | |
| 1.692 | *Yellow* | **Blue** | *Bandylite* | Bor. | − | 0° | X⊥001 cl. | * |
| | | | **III. Yellow Minerals, not Pleochroic, but Anisotropic** | | | | | |
| | | | (c) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| **2.07** | Yellow | | *Curite* | Uran. | ? | ? | G.=7.19 | 103 |
| | | | **IV. Yellow Minerals, Pleochroic in Yellow (Including Orange to Colorless)** | | | | | |
| | | | (c) Birefringence rather strong. $N_g-N_p>0.0185<0.0275$ | | | | | |
| 1.736 | Colorless | Yellow | *Renardite* | Phos. | − | 70° | Y=yellow. X=*a* | 148 |
| 1.89 | *Yellow* | ? | *Dumontite* | Phos. | + | Lg. | Y=dark yellow | 148 |
| | | | (d) Birefringence strong. $N_g-N_p>0.0275<0.0365$ | | | | | |
| 1.686 | Colorless | **Yellow** | *β-Uranotile* | Sil. | − | 65° | Y=deep yellow. Z∧*c*=41° | ** |
| | | | (e) Birefringence very strong: $N_g-N_p>0.0365<0.0545$ | | | | | |
| 1.542 | *Yellow* | *Gr.-yellow* | *Dakeite* | Sul. | − | 5° | 001 cl. | *** |
| | | | (f) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | |
| 1.575 | Colorless | Br.-yellow | *Metasideronatrite* | Sul. | + | 60° | Y=yellow. Z=*c* | *4 |
| 1.630 | *Yellow* | Gr.-yellow | *Guildite* | Sul. | + | Sm. | 001 and 100 cl. | 117 |
| 1.650 | Colorless | *Yellow* | *Krausite* | Sul. | + | Lg. | X∧*c*=; 35° | 115 |
| 1.663 | *Yellow* | Br.-yellow | *Parabutlerite* | Sul. | + | 87° | Y=gr.-yellow. G.=2.55 | *4 |
| 1.674 | *Br.-yellow* | *Canary-yellow* | *Butlerite* | Sul. | − | Lg. | 001 cl. | 108 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.690 | ? | Yellow | *Legrandite* | Phos. | + | 27° | Y=colorless | 137 |
| 1.732 | Red-yellow | Gr.-yellow | *Lopezite* | Chrom. | + | 50° | Y=yellow. 010 cl. | *5 |
| 2.098 | Light to dark orange | | *Clarkeite* | Uran. | − | 40°± | G.=6.4 | 111 |

### V. Minerals Pleochroic in Yellow and Brown

(a) Birefringence very weak to moderate. $N_g - N_p < 0.0185$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.728 | **Brown** | Yellow | *Landesite* | Phos. | − | Lg. | Y=*brown*. X=*c* | 156 |

(c) Birefringence strong to very strong. $N_g - N_p > 0.0275 < 0.0545$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.78± | Yellow | Red-brown | *Taosite* | Ox. | − | 0° | Assoc. with spinel | *6 |

(d) Birefringence extreme: $N_g - N_p > 0.0545$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.643 | *Yellow* | **Gr.-brown** | *Hohmanite* | Sul. | − | 40° | 010 cl. Y=*gr. yellow* | *7 |
| 1.718 | *Yellow* | Red-brown | *Metahohmanite* | Sul. | + | 70° | Y=red−yellow | *7 |
| 1.905 | Yellow | Brown | *Argentojarosite* | Sul. | − | 0° | 0001 cl. | 114 |

### VI. Minerals Pleochroic in Yellow and Red

(e) Birefringence extreme: $N_g - N_p > 0.0545$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.643 | ? | Br.-red | *Castanite* | Sul. | − | Mod. | Y=yellow. $X \wedge c = 22°$ in 010 | 110 |
| 1.725 | *Red* | **Red** | *Bermanite* | Phos. | − | 74° | Y=*yellow*. X=*c* | *8 |

* C. Palache and W. F. Foshag: *Am. Mineral.*, XXIII, 1938, p. 85.
** R. Nováček: *Mineral. Abst.*, VI, 1935, p. 149.
*** E. S. Larsen and F. A. Gonyer: *Am. Mineral.*, XXII, 1937, p. 561.
*4 M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 714.
*5 M. C. Bandy: *Am. Mineral.*, XXII, 1937, p. 929.
*6 J. de Lapparent: *Comp. Rend.*, CCI, 1935, p. 154.
*7 M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 714.
*8 C. S. Hurlbut: *Am. Mineral.*, XXI, 1936, p. 656.

## SUPPLEMENTARY TABLE III.—COLOR OF MINERALS

### VIII. Brown Minerals, Not Pleochroic, But Anisotropic

| $N_o$ or $N_m$ | X | Z | Mineral | Chem. | ± | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| (b) Birefringence rather strong to strong. $N_g-N_p>0.0185<0.0365$ | | | | | | | | |
| 1.749 | Brown | | *Allodelphite* | Arsen. | − | 0°± | G. = 3.57 | 440 |
| **IX. Brown Minerals Pleochroic in Brown** | | | | | | | | |
| (c) Birefringence strong to very strong: $N_g-N_p>0.0275<0.0545$ | | | | | | | | |
| 1.864 | *Brown* | **Red-brown** | *Plumbosynadelphite* | Arsen. | + | 40° | Y = brown | * |
| 1.930 | Brown, weakly pleochroic | | *Fersmanite* | Tit. | − | 3°± | Y = *b*. G. = 3.44 | 168 |
| **X. Minerals Pleochroic in Brown and Red** | | | | | | | | |
| (c) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | | | | |
| 1.765 | **Pink** | **Brown** | *Murmanite* | Sil. | − | 64° | Y = clear brown. G. = 2.84 | ** |
| **XVII. Blue Minerals, Not Pleochroic But Anisotropic** | | | | | | | | |
| (a) Birefringence very weak to very strong: $N_g-N_p<0.0545$ | | | | | | | | |
| 1.512 | Pale blue | | *Mg-Chalcanthite* | Sul. | − | 55° | G. = 1.72 | *** |
| **XVIII. Blue Minerals, Pleochroic in Blue** | | | | | | | | |
| (c) Birefringence rather strong: $N_g-N_p>0.0185<0.0275$ | | | | | | | | |
| 1.735 | Lavender | Lavender | *Hodgkinsonite* | Sil. | − | Mod. | Y = colorless | 412 |
| (f) Birefringence extreme: $N_g-N_p>0.0545$ | | | | | | | | |
| 1.90 | Colorless | **Violet** | *Ianthinite* | Oxal. | − | Sm. | Y = violet. X ⊥ 100 cl. | 60 |

XIX. MINERALS PLEOCHROIC IN BLUE AND GREEN

(c) Birefringence rather strong. $N_g - N_p > 0.0185 < 0.0275$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.636 | Grass green | Sky blue | *Mitscherlichite* | Hal. | − | 0° | G. = 2.42 | 34 |

(e) Birefringence extreme: $N_g - N_p > 0.0545$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.685 | Green | *Blue* | *Antofagastite* | Hal. | + | 75° | Y = olive green. 110, 001 cl. | *4 |

XXI. GREEN MINERALS, NOT PLEOCHROIC BUT ANISOTROPIC

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.002 | Green | *Lindgrenite* | Molyb. | − | 71° | Z⊥010 cl. G. = 4.26 | *5 |

XXII. GREEN MINERALS, PLEOCHROIC IN GREEN

(b) Birefringence weak. $N_g - N_p > 0.0035 < 0.0095$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.622 | *Bluish green* | Bluish green | *Garnierite* | Sil. | + | 0°± | Fibrous | *6 |

(e) Birefringence strong: $N_g - N_p > 0.0275 < 0.0365$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.78± | Green to colorless | *Vandenbrandeite* | Uran. | ? | ? | Abn. int. colors | *7 |

XXIII. MINERALS PLEOCHROIC IN GREEN AND YELLOW

(a) Birefringence very weak to weak: $N_g - N_p < 0.0095$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.71± | Olive green | Green | *Tawmawite* | Sil. | − | 50° | Y = yellow to brown | *8 |

* C. S. Hurlbut: *Am. Mineral.*, XXII, 1937, p. 526.
** A. E. Fersman: *Mineral. Abst.*, II, p. 263; also V, 1933, p. 198.
*** J. J. Glass in Charles Milton and W. D. Johnston: *Econ. Geol.*, XXXIII, 1938, p. 761.
*4 C. Palache and W. F. Foshag: *Am. Mineral.*, XXIII, 1938, p. 85.
*5 C. Palache: *Am. Mineral.*, XX, 1935, p. 484.
*6 K. Spangenberg: *Zent. Mineral.*, 1938, A, p. 360.
*7 A. Schoep: *N. Jahrb. Mineral.*, 1933, I, p. 250.
*8 P. Eskola: *C. R. Soc. Géol. Finlande*, 7, 1933, p. 26.

## TABLE IV.—REFRINGENCE OF MINERALS

THE refringence of minerals in thin section can be estimated or measured by the methods described in Part I of this work on pages 76–79 and 83–85. Accordingly, the following table can be used to good advantage in the study of thin sections in some cases. It is still more useful in the study of powdered minerals, since the refringence of such material can be measured much more accurately by the immersion methods described on pages 79–82, 228–239, and 244–253.

The table of refringence of minerals is divided into two parts, namely, one part including the isotropic minerals, and a second part including the anisotropic minerals. In each part the minerals are arranged in the order of increasing refringence as determined by N, the single index of refraction of the isotropic minerals, and by $N_o$ or $N_m$ for the anisotropic minerals. In the second part of the table (dealing with anisotropic minerals) the indices of refraction are arranged in the first column with indices of positive minerals at the extreme left side and indices of negative minerals indented two spaces to the right. The indices of a few minerals of variable or uncertain sign are in an intermediate position, indented one space to the right.

Many minerals vary more or less in chemical composition and therefore in their physical properties, including their refringence. Such variations are shown by entering each mineral in its proper place as determined by the lowest known value for the refringence (N, $N_o$ or $N_m$), and entering it again for the highest known value, and connecting these two entries by a vertical line (to the right of the column of indices of refraction) expressing the entire range of variation. Furthermore, when the range of variation of any mineral carries it beyond one page, the mineral is repeated with its minimum index at the head of the next page, so that all minerals having an index within a certain range are listed on any page.

In the second part of the table devoted to anisotropic minerals, the second and third columns give the greatest and least indices of refraction of each mineral, or, if they are unknown, the birefringence ($N_g - N_p$) of the mineral. The fifth column gives the chemical

formula of each mineral when that formula is very short; in other cases it gives the chemical nature of the mineral usually by naming the class of chemical salts to which it belongs, such as carbonate, halide, or silicate. The sixth column gives the crystallographic direction of the cleavage of each mineral and expresses the optic orientation as related to that cleavage; in case the mineral has no cleavage its optic orientation is expressed in relation to its crystal axes. The seventh column gives such other characters as seem most important in each case. The last column gives the page in Part II of this work where a more complete description may be found.

For methods of estimating or measuring the birefringence, see Part I, pages 119–123 and 136–138.

For a discussion of cleavage, see Part I, pages 29–32.

For methods of determining pleochroic formulas, see Part I, pages 170, 171, 204, and 211.

For definitions of X, Y and Z, see Part I, pages 117 and 160.

For methods of distinguishing between X, Y and Z, see Part I, pages 124, 130, and 211.

For methods of determining the optic sign, see Part I, pages 129–135, 138, 148–152, 169, and 206–213.

For methods of estimating or measuring the optic axial angle, see Part I, pages 186–189, 210, 226–227, and 239–244.

For methods of determining the optic orientation of a mineral, see Part I, pages 170, 171, 205, and 212.

For methods of measuring extinction angles, see Part I, pages 126, 137, 173, 174, and 178.

For a list of abbreviations used in the table, see page xiii.

## TABLE IV A.—REFRINGENCE OF ISOTROPIC MINERALS

| N | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|
| 1.339 | *Hieratite* | $K_2SiF_6$ | 111 | G.=2.75. Also hex. | 36 |
| 1.3395 | *Cryolithionite* | Hal. | 110 | G.=2.78. Oct. | 34 |
| 1.39 | *Hieratite* | $K_2SiF_6$ | 111 | G.=2.75. Also hex. | 36 |
| 1.403 | *Termierite* | Sil. | None | Clay-like. Also biref. | 115 |
| 1.406 | Opal | Ox. | None | G.=2.1. Sol. HF | 57 |
| 1.427 | *Ralstonite* | Hal. | None | G.=2.61. Also biref. | 36 |
| 1.434 | Fluorite | $CaF_2$ | 111 | White or tinted | 31 |
| 1.435 | *Yttrocerite* | Hal. | 111 | G.=3.5. Violet | 36 |
| 1.439 | *Sodalumite* | Sul. | ? | G.=1.69. Also biref. | 113 |
| 1.44-5 | *Yttrofluorite* | Hal. | 111 | Yellow or green | 35 |
| 1.45 | *Hisingerite* | Sil. | None | Data vary. Brown | 415 |
| 1.45 | *Melanophlogite* | Ox. | None | Cubic. Yellow± | 54 |
| 1.453 | *Potassalumite* | Sul. | None | G.=1.76. Also biref. | 113 |
| 1.454 | *Sulfohalite* | Sul. | None | G.=2.49. Dodec. | 118 |
| 1.458 | *Lechatelierite* | $SiO_2$ | None | G.=2.19. Sol. HF | 57 |
| 1.458 | *Tschermigite* | Sul. | None | G.=1.64. Sol. $H_2O$ | 113 |
| 1.46 | Opal | Ox. | None | G.=2.1. Sol. HF | 57 |
| 1.461 | *Melanophlogite* | Ox. | None | Cubic. Yellow± | 54 |
| 1.47 | *Hisingerite* | Sil. | None | Data vary. Brown | 415 |
| 1.47 | *Allophane* | Sil. | None | G.=1.87. Sol. HCl | 415 |
| 1.47 | Halloysite | Sil. | None | G.=2.1. Data vary | 415 |
| 1.47± | *Neotocite* | Sil. | None | G.=2.7. Brown | 413 |
| 1.479 | **Analcite** | Sil. | None | G.=2.25. Also biref. | 293 |
| 1.48 | *Faujasite* | Sil. | 111 | G.=1.92. Also biref. | 382 |
| 1.48 | Noselite | Sil. | None | White or tinted | 290 |
| 1.483 | **Sodalite** | Sil. | None | White or tinted | 289 |
| 1.485 | *Evansite* | Phos. | None | G.=1.94. Concretions | 145 |
| 1.486 | *Metacristobalite* | $SiO_2$ | ? | G.=2.27. Metastable | 54 |
| 1.487 | **Sodalite** | Sil. | None | White or tinted | 289 |
| 1.487 | *Hackmanite* | Sil. | None | Color fades | 290 |
| 1.489 | **Analcite** | Sil. | None | G.=2.25. Also biref. | 293 |
| 1.49 | *Allophane* | Sil. | None | G.=1.87. Sol. HCl | 415 |
| 1.49 | *Vashegyite* | Phos. | None | G.=1.96. Sol. HCl | 144 |
| 1.49 | *Succinite* | $C_{12}H_{20}O$ | None | G.=1.07. Yellow | 89 |
| 1.49 | Sylvite | KCl | 100 | G.=1.98. Cubes | 30 |
| 1.495 | Noselite | Sil. | None | White or tinted | 290 |
| 1.496 | Hauynite | Sil. | None | Blue, green, etc. | 290 |
| 1.5 | *Rosiéresite* | Phos. | None | G.=2.2. Yellow | 145 |
| 1.50± | Lazurite | Sil. | None | G.=2.4±. Blue | 290 |
| 1.50 | *Stevensite* | Sil. | None | Like talc | 419 |
| 1.50± | *Montmorillonite* | Sil. | None | G.=2±. Sol. HF | 434 |
| 1.504 | *Vashegyite* | Phos. | None | G.=1.96. Sol. HCl | 144 |
| 1 508 | **LEUCITE** | Sil. | None | G.=2.47. Also biref. | 291 |
| 1.508 | *Tychite* | Carb. | None | G.=2.46. Sol. HCl | 118 |
| 1.51 | Hauynite | Sil. | None | Blue, green, etc. | 290 |

TABLE IV A.—REFRINGENCE OF ISOTROPIC MINERALS—*continued*

| N | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|
| 1.47 | Halloysite | Sil. | None | G.=2.1. Data vary | 415 |
| 1.49 | *Succinite* | $C_{12}H_{20}O$ | None | G.=1.07. Yellow | 89 |
| 1.50 | *Montmorillonite* | Sil. | None | G.=2±. Sol. HF | 434 |
| 1.514 | *Northupite* | Carb. | None | G.=2.38. Also biref. | 85 |
| 1.517 | *β-Sepiolite* | Sil. | None | White or yellow | 410 |
| 1.517 | *Planerite* | Phos. | None | G.=2.65. Green | 145 |
| 1.52 | *Kehoeite* | Phos. | None | G.=2.34. Chalky | 158 |
| 1.525 | *Pollucite* | Sil. | None | G.=2.9. Sol. HCl | 293 |
| 1.525 | *Cornuite* | Sil. | None | Green, blue, brown | 413 |
| 1.53 | *Spadaite* | Sil. | None | Red in mass | 413 |
| 1.53 | **Allanite** | Sil. | ? | Alteration product | 316 |
| 1.53 | *Neotocite* | Sil. | None | G.=2.7. Brown | 413 |
| 1.535 | *Langbeinite* | Sul. | None | G.=2.83. Hygrosc. | 110 |
| 1.538 | *Indianaite* | Sil. | None | G.=2.3–2.5 | 415 |
| 1.54 | *Kehoeite* | Phos. | None | G.=2.34. Chalky | 158 |
| 1.543 | *Succinite* | $C_{12}H_{20}O$ | None | G.=1.07. Yellow | 89 |
| 1.544 | Halite | NaCl | 100 | G.=2.17. Sol. $H_2O$ | 29 |
| 1.55 | *Montmorillonite* | Sil. | None | G.=2±. Sol. HF | 434 |
| 1.55 | *Cornuite* | Sil. | None | Green, blue, brown | 413 |
| 1.555 | *Collyrite* | Sil. | None | G.=2±. Sol. HF | 435 |
| 1.56 | *Neotocite* | Sil. | None | G.=2.7. Brown | 413 |
| 1.56 | *Zaratite* | Carb. | None | Green. Also biref. | 85 |
| 1.56± | Bauxite | Ox. | None | G.=2.55. Sol. KOH | 49 |
| 1.569 | Collophane | Phos. | None | Also biref. In sediments | 161 |
| 1.57 | Halloysite | Sil. | None | G.=2.1. Data vary | 415 |
| 1.57 | *Borickite* | Phos. | None | G.=2.7. Brown | 157 |
| 1.584 | *Schroetterite* | Sil. | None | White, green, brown | 415 |
| 1.589 | *Zunyite* | Sil. | 111 | G.=2.87. Sol. HF | 414 |
| 1.59± | *Hisingerite* | Sil. | None | G.=3. Brown | 415 |
| 1.59 | *Garnierite* | Sil. | None | Green. Sol. HCl | 261 |
| 1.59 | *Kochite* | Sil. | ? | G.=2.93 | 414 |
| 1.60± | *Stibiconite* | Ox. | None | G.=5.2. Also biref. | 68 |
| 1.602 | *Zunyite* | Sil. | 111 | G.=2.87. Sol. HF | 414 |
| 1.602 | *Voltaite* | Sul. | None | G.=2.79. Oil-green | 115 |
| 1.61 | *Zaratite* | Carb. | None | Green. Also biref. | 85 |
| 1.61 | Bauxite | Ox. | None | G.=2.55. Sol. KOH | 49 |
| 1.61± | *Gummite* | Ox. | None | G.=4±. Sol. HCl | 68 |
| 1.618 • | *Diadochite* | Sul. | None | White or yellow | 121 |
| 1.625 | Collophane | Phos. | None | Also biref. In sediments | 161 |
| 1.63 | *Griphite* | Phos. | None | G.=3.4. Brown | 155 |
| 1.635± | *Pitticite* | Sul. | None | Brown to white | 121 |
| 1.64 | *Picite* | Phos. | None | G.=2.83. Yellow | 145 |
| 1.64± | *Lagonite* | Bor. | None | Yellow. Rare | 94 |
| 1.640 | *Homilite* | Sil. | Poor | Also biref. with $N_m$=1.72± | 424 |
| 1.642 | *Salammoniac* | $NH_4Cl$ | 111 | G.=1.53. Sol. $H_2O$ | 30 |

TABLE IV A.—REFRINGENCE OF ISOTROPIC MINERALS—*continued*

| N | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|
| 1.53 | **Allanite** | Sil. | ? | Alteration product | 316 |
| 1.57 | *Borickite* | Phos. | None | G. = 2.7. Brown | 157 |
| 1.60 | *Stibiconite* | Ox. | None | G. = 5.2. Also biref. | 68 |
| 1.618 | *Diadochite* | Sul. | None | White or yellow | 121 |
| 1.63 | *Griphite* | Phos. | None | G. = 3.4. Brown | 155 |
| 1.65 | *Griphite* | Phos. | None | G. = 3.4. Brown | 155 |
| 1.652± | *Greenalite* | Sil. | None | G. = 2.8+. Green, brown | 413 |
| 1.67 | *Borickite* | Phos. | None | G. = 2.7. Brown | 157 |
| 1.67 | *Hibschite* | Sil. | None | G. = 3.05. Sol. HCl | 429 |
| 1.675 | *Plazolite*[1] | Sil. | None | G. = 3.13. Dodec. | 183 |
| 1.676 | *Pharmacosiderite* | Phos. | 100 | G. = 3.0. Green, yellow | 143 |
| 1.68 | *Thorite* | $ThSiO_4$ | 110 | G. = 5.3±. Yellow | 185 |
| 1.69 | *Rhodizite* | Bor. | 111 | Biref. very weak | 94 |
| 1.70 | **Allanite** | Sil. | ? | Alteration product | 316 |
| 1.70 | *Diadochite* | Sul. | None | White or yellow | 121 |
| 1.70 | *Polycrase* | Colum. | None | G. = 5. Brown | 167 |
| 1.70 | **Pyralspite** | Sil. | None | Red±. Dodec. | 178 |
| 1.705 | **Pyrope** | Sil. | None | Red±. Dodec. | 178 |
| 1.72 | *Thorite* | $ThSiO_4$ | 110 | G. = 5.3±. Yellow | 185 |
| 1.72 | *Delvauxite* | Phos. | None | G. = 1.9±. Brown | 145 |
| 1.723 | Spinel | $MgAl_2O_4$ | 111 | Red, blue, yellow, etc. | 62 |
| 1.725 | *Rowlandite* | Sil. | None | G. = 4.5. Green | 420 |
| 1.727 | *Berzelite* | Arsen. | None | G. = 4. Yellow | 122 |
| 1.73 | *Tritomite* | Sil. | Poor | G. = 4.2. Brown | 420 |
| 1.73 | **Ugrandite** | Sil. | None | Green, yellow, red | 180 |
| 1.735 | **Grossularite** | Sil. | None | White to brown | 180 |
| 1.736± | *Periclase* | MgO | 100 | G. = 3.65. Sol. HCl | 41 |
| 1.737 | *Danalite* | Sil. | 111 | G. = 3.43. Pink± | 291 |
| 1.739 | *Helvite* | Sil. | 111 | G. = 3.2. Yellow± | 291 |
| 1.74 | *Pilbarite* | Ox. | None? | G. = 4.6. Yellow | 185 |
| 1.74 | *Caryocerite* | Sil. | None | G. = 4.29. Brown | 420 |
| 1.755 | *Arsenolite* | $As_2O_3$ | ? | G. = 3.71. Oct. | 43 |
| 1.758 | *Yttrialite* | Sil. | ? | G. = 4.58. Green | 414 |
| 1.76 | *Tritomite* | Sil. | Poor | G. = 4.2. Brown | 420 |
| 1.77 | **Pyrope** | Sil. | None | Red±. Dodec. | 178 |
| 1.77 | *Mackintoshite* | Ox. | ? | G. = 5.44. Cloudy | 185 |
| 1.77 | *Melanocerite* | Sil. | None | Reddish brown | 420 |
| 1.77 | **Almandite** | Sil. | None | Red±. Dodec. | 178 |
| 1.77 | *Hercynite* | $FeAl_2O_4$ | None? | G. = 3.9. Green | 62 |
| 1.78± | *Gadolinite* | Sil. | None | G. = 4±. Green | 424 |
| 1.79 | *Gahnite* | $ZnAl_2O_4$ | 111 | G. = 4.5. Green | 63 |
| 1.79 | **Spessartite** | Sil. | None | G. = 4±. Red± | 178 |
| 1.80 | Spinel | $MgAl_2O_4$ | 111 | G. = 3.6. Red, blue, etc. | 62 |
| 1.8± | *Manganspinel* | $MnAl_2O_4$ | None | G. = 4.05. Brown | 62 |
| 1.81 | *Gahnite* | $ZnAl_2O_4$ | 111 | G. = 4.5. Green | 63 |

1. N as corrected in *Am. Mineral.*, IX, 1924, p. 94.

TABLE IV A.—REFRINGENCE OF ISOTROPIC MINERALS—*continued*

| N | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|
| 1.60 | *Stibiconite* | Ox. | None | G.=5.2. Also biref. | 68 |
| 1.70 | **Pyralspite** | Sil. | None | Red±. Dodec. | 178 |
| 1.73 | **Ugrandite** | Sil. | None | Green, yellow, red | 180 |
| 1.735 | **Grossularite** | Sil. | None | White to brown | 180 |
| 1.77 | **Almandite** | Sil. | None | Red±. Dodec. | 178 |
| 1.77 | *Hercynite* | $FeAl_2O_4$ | None? | G.=3.9. Green | 62 |
| 1.79 | **Spessartite** | Sil. | None | G.=4±. Red± | 178 |
| 1.81 | **Grossularite** | Sil. | None | White to brown | 180 |
| 1.81 | **Spessartite** | Sil. | None | G.=4±. Red | 178 |
| 1.812 | *Beckelite* | Sil. | 100 | Yellow. Also biref. | 420 |
| 1.818 | *Naegite* | Ox. | ? | Green or brown | 65 |
| 1.82 | **Andradite** | Sil. | None | Yellow to red | 180 |
| 1.82 | *Malacon* | Ox. | None | G.=4–4.3. Also biref. | 184 |
| 1.82 | *Roméite* | Antim. | 111 | Yellow. Also biref. | 159 |
| 1.83 | **Pyralspite** | Sil. | None | Red±. Dodec. | 178 |
| 1.83 | **Almandite** | Sil. | Poor | Red±. Dodec. | 178 |
| 1.83 | *Uvarovite* | Sil. | None | Green. Dodec. | 180 |
| 1.84 | *Bindheimite* | Antim. | 111 | Yellow. Also biref. | 160 |
| 1.86 | Schorlomite | Sil. | None | Has $TiO_2$. Brown | 183 |
| 1.87 | *Uvarovite* | Sil. | None | Green. Dodec. | 180 |
| 1.87 | *Bindheimite* | Antim. | 111 | Yellow. Also biref. | 160 |
| 1.87 | *Stibiconite* | Ox. | None | G.=5.2. Also biref. | 68 |
| 1.87 | *Roméite* | Antim. | 111 | Yellow. Also biref. | 159 |
| 1.87 | *Chalcolamprite* | Colum. | ? | G.=3.77. Brown | 164 |
| 1.90 | **Ugrandite** | Sil. | None | Green, yellow, red | 180 |
| 1.90 | *Hercynite* | $FeAl_2O_4$ | None? | G.=3.9. Green | 62 |
| 1.90 | **Andradite** | Sil. | None | Yellow to red | 180 |
| 1.91 | *Cervantite* | Ox. | None? | G.=4. Sol. HCl | 67 |
| 1.92± | *Betafite* | Titan. | ? | G.=4. Green | 164 |
| 1.92 | *Samirésite* | Colum. | ? | G.=5.24. Yellow | 164 |
| 1.93 | *Microlite* | Tant. | ? | G.=5.5. Yellow | 164 |
| 1.93 | *Malacon* | Ox. | None | G.=4–4.3. Also biref. | 184 |
| 1.93 | *Nantokite* | CuCl | 100 | G.=3.93. Sol. $H_2O$ | 30 |
| 1.95 | *Neotantalite* | Tant. | ? | G.=5.19. Yellow | 164 |
| 1.96 | *Samirésite* | Colum. | ? | G.=5.24. Yellow | 164 |
| 1.96± | ***Pyrochlore*** | Titan. | 111 | G.=4.3. Yellow | 163 |
| 1.98± | ***Hatchettolite*** | Colum. | ? | G.=4.8±. Yellow± | 164 |
| 1.99 | ***Neotantalite*** | Tant. | ? | G.=5.19. Yellow | 164 |
| 1.998 | Sulfur (fused) | S | None | G.=2. Yellow | 14 |
| 2.00 | *Wiikite* | Colum. | ? | Yellow. Also biref. | 167 |
| 2.0 | **Limonite** | Ox. | None | G.=3.8. Yellow | 47 |
| 2.01 | Schorlomite | Sil. | None | Has $TiO_2$. Brown | 183 |
| 2.05± | Picotite | Ox. | 111 | G.=4.1. Brown | 62 |
| 2.05 | ***Risoerite*** | Tant. | ? | G.=4.18. Brown | 165 |
| 2.05 | ***Eulytite*** | Sil. | 110 | G.=6.1. Yellow | 414 |

TABLE IV A.—REFRINGENCE OF ISOTROPIC MINERALS—*continued*

| N | Mineral | Chem. | Cleav. | Other characters | Page |
|---|---|---|---|---|---|
| 1.91 | *Cervantite* | Ox. | None? | G.=4. Sol. HCl | 67 |
| 2.0 | **Limonite** | Ox. | None | G.=3.8. Yellow | 47 |
| 2.05–6 | *Percylite* | Hal. | 100 | G.=2.25. Blue | 37 |
| 2.06 | *Cervantite* | Ox. | None? | G.=4. Sol. HCl | 67 |
| 2.06 | *Euxenite* | Titan. | None | G.=4.8. Brown | 167 |
| 2.06 | *Cerargyrite* | Hal. | None | G.=5.4–6. Horny | 30 |
| 2.065 | *Mosesite* | Hal. | None | Yellow. Also biref. | 34 |
| 2.07 | **Chromite** | $FeCr_2O_4$ | None | Opaque to brown | 62 |
| 2.087 | *Senarmontite* | $Sb_2O_3$ | 111 | G.=5.2. Also biref. | 43 |
| 2.09 | *Schneebergite* | Antim. | 111 | G.=5.4. Yellow | 160 |
| 2.10 | *Samarskite* | Colum. | 010 | Brown. Also biref. | 166 |
| 2.10 | *Fergusonite* | Colum. | 111 | Brown. Also biref. | 164 |
| 2.12 | *Yttrocrasite* | Titan. | None? | Yellow. Also biref. | 167 |
| 2.12 | *Koppite* | Tant. | None | G.=4.5. Red | 164 |
| 2.13 | *Ampangabéite* | Colum. | None? | G.=4.2±. Red | 166 |
| 2.14 | *Blomstrandinite* | Titan. | 010 | G.=4.9±. Brown | 167 |
| 2.15 | *Yttrocrasite* | Titan. | None? | Yellow. Also biref. | 167 |
| 2.15± | *Embolite* | Hal. | None | G.=5.8. Yellow | 30 |
| 2.15 | *Yttrotantalite* | Tant. | 010 | G.=5.7±. Brown | 166 |
| 2.15 | *Bismutite* | Carb. | None | G.=7.0. Efferv. HCl | 86 |
| 2.16 | **Chromite** | $FeCr_2O_4$ | None | Opaque to brown | 62 |
| 2.16 | *Manganosite* | MnO | 100 | G.=5.18. Green | 41 |
| 2.16 | *Pyrrhite* | Tant. | None? | G.=4.5±. Red | 164 |
| 2.18 | *Koppite* | Tant. | None? | G.=4.5. Red | 164 |
| 2.19 | *Fergusonite* | Colum. | 111 | Brown. Also biref. | 164 |
| 2.19 | *Zirkelite* | Ox. | None | G.=4.72. Brown | 164 |
| 2.20± | *Iodembolite* | Hal. | None | G.=5.7. Yellow | 30 |
| 2.20 | *Thorianite* | Ox. | None? | G.=9.32. Brown | 50 |
| 2.20 | *Lewisite* | Antim. | 111 | G.=4.95. Yellow | 162 |
| 2.20 | *Miersite* | Hal. | 110 | G.=5.64. Yellow | 30 |
| 2.20 | *Eschynite* | Titan. | None? | G.=5.0±. Brown | 167 |
| 2.21 | *Weslienite* | Antim. | None | Yellow. Also biref. | 160 |
| 2.215 | *Polymignite* | Titan. | Poor | G.=4.8. Brown | 167 |
| 2.23 | *Bunsenite* | NiO | ? | G.=6.4. Green, brown | 41 |
| 2.25 | *Samarskite* | Colum. | 010 | Brown. Also biref. | 166 |
| 2.25± | *Bromyrite* | AgBr | None | G.=6.0. Yellow | 30 |
| 2.26± | *Cerargyrite* | Hal. | None | G.=5.4–6. Horny | 30 |
| 2.26 | *Euxenite* | Titan. | None | G.=4.8. Brown | 167 |
| 2.26 | *Bismutite* | Carb. | None | G.=7.0. Also biref. | 86 |
| 2.26 | *Eschynite* | Titan. | None | G.=5.0±. Brown | 167 |
| 2.27 | *Iron* | Fe | 100 | Opaque. Sol. HCl | 16 |
| 2.30 | **Limonite** | Ox. | None | G.=3.8. Yellow, red | 47 |
| 2.30 | *Brannerite* | Ox. | None | G.=5.1. Green, brown | 69 |

TABLE IV A.—REFRINGENCE OF ISOTROPIC MINERALS—*continued*

| N | | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|---|
| 2.30± | | *Jacobsite* | $MnFe_2O_4$ | ? | G. = 4.75. Brown | 63 |
| 2.30 | | *Knopite* | Titan. | 100 | Brown. Also biref. | 163 |
| 2.33 | | *Dysanalite* | Titan. | 100 | Green. Also biref. | 163 |
| 2.346 | | *Marshite* | CuI | 110 | G. = 5.59. Yellow | 30 |
| 2.35 | | *Magnesioferrite* | $MgFe_2O_4$ | None | Opaque to red | 61 |
| 2.36 | | Franklinite | Ox. | 111 | Opaque to brown | 63 |
| 2.37 | ↑ | Sphalerite | ZnS | 110 | G. = 4.09. Brown± | 19 |
| 2.38 | \| | Perovskite | $CaTiO_3$ | 100 | Gray, etc. Also biref. | 163 |
| 2.419 | \| | Diamond | C | 111 | G. = 3.5. H. = 10 | 13 |
| 2.42 | \| | **MAGNETITE** | $Fe_3O_4$ | 110 | Opaque. G. = 5.17 | 63 |
| 2.47 | ↓ | Sphalerite | ZnS | 110 | G. = 3.94. Brown | 19 |
| 2.49 | | *Eglestonite* | Hal. | None | G. = 8.33. Yellow | 37 |
| 2.69 | | *Hauerite* | $MnS_2$ | 100 | G. = 3.46. Red | 24 |
| 2.70 | | *Alabandite* | MnS | 100 | G. = 4.0. Green | 20 |
| >2.72 | | *Tennantite* | $Cu_6As_2S_6$ | None | Red to opaque | 26 |
| >2.72 | | Tetrahedrite | $Cu_6Sb_2S_6$ | None | G. = 4.4. Red | 26 |
| 2.849 | | Cuprite | $Cu_2O$ | 111 | G. = 6. Red | 40 |
| 2.92 | | *Selenium* (fused) | Se | None | G. = 4.7±. Red | 15 |
| Extreme | | *Blomstrandite* | Titan. | None | G. = 4.2. Brown | 167 |

SUPPLEMENTARY TABLE IV A.—REFRINGENCE OF ISOTROPIC MINERALS

| N | Mineral | Chem. | Cleav. | Other Characters | Page |
|---|---|---|---|---|---|
| 1.369 | Cryptohalite | Hal. | 111 | G. = 2.00. Sol. in $H_2O$ | 36 |

## TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ or $N_g-N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.309 | | 1.313 | 1.309 | **Ice** | $H_2O$ | 0001 ⊥ Z | Hex. G. = 0.92 | 40 |
| | 1.312 | 1.312 | 1.309 | *Malladrite* | Hal. | X = *c* | Ps.Hex. twin. G. = 2.75 | 37 |
| | 1.326 | Very weak | | *Avogadrite* | Hal. | X = *c* | Y = *b*. 2V = Lg. G. = 2.62 | 34 |
| | 1.328 | Very weak | | *Villiaumite* | NaF | 100 | X = yellow, Z = red | 30 |
| 1.339 | | .001 | | *Cryolite* | $Na_3AlF_6$ | 001, 110 | X = *b*. $Z\wedge c=-44°$; 2V = 43° | 34 |
| | 1.349 | 1.349 | 1.343 | *Chiolite* | $Na_2AlF_5$ | 001 ⊥ X | Tet. G. = 3.0 | 34 |
| 1.378 | | 1.390 | 1.378 | *Sellaite* | $MgF_2$ | 100, 110 | Tet. G. = 3.17 | 32 |
| | 1.396 | 1.398 | 1.394 | Mirabilite | Sul. | 100 | $Z\wedge c=+29°$. 2V = 80°. Sol. $H_2O$ | 97 |
| 1.40? | | Mod. | | Chryscolla | Sil. | Z = *c* | Green or brown | 44 |
| | 1.403 | .002 | | *Termierite* | Sil. | ? | G. = 1.2? | 415 |
| 1.413 | | .008 | | *Pachnolite* | Hal. | $Z\wedge c=+68°$ | X = *b*; 2V = 76° | 36 |
| | 1.414 | 1.415 | 1.407 | *Thomsenolite* | Hal. | 001; Z = *b* | $X\wedge c=-52°$; 2V = 50° | 36 |
| 1.44 | | 1.452 | 1.438 | *Erionite* | Sil. | Z = *c* | Orth. G. = 2.0 | 389 |
| 1.448 | | 1.450 | 1.447 | *Variscite* (−$H_2O$) | Phos. | | Z = *a* = lavender; *c* = violet | 140 |
| 1.448 | | 1.459 | 1.447 | *Taylorite* | Sul. | ? | 2V = 36°. Orth.? | 96 |
| | 1.45± | Very weak | | *Yttrocalcite* | Hal. | $10\bar{1}0$ | G. = 3.19 | 36 |
| 1.45 | | Weak | | *Covellite* | CuS | 0001 ⊥ Z | Green to opaque | 20 |
| | 1.452 | 1.458 | 1.430 | Kalinite | Sul. | $Y\wedge c=13°$ | Z = *b*; 2V = 52° | 113 |
| | 1.452 | 1.453 | 1.440 | *Lecontite* | Sul. | 110 at 76° | X = *a*. Y = *c*. 2V = 40° | 97 |
| | 1.454 | 1.456 | 1.448 | *Gearksutite* | Hal. | $Y\wedge c$ = Lg. | X = *b*. 2V = Mod. | 35 |
| | 1.455 | 1.461 | 1.433 | Epsomite | Sul. | 010 ⊥ X | Y = *c*. 2V = 51° | 103 |
| | 1.455 | 1.459 | 1.435 | *Wattevillite* | Sul. | $X\wedge$fib. = 0° − Lg. | 2V = 48° | 112 |
| | 1.455 | 1.456 | 1.434 | *Mendozite* | Sul. | X ‖ fib. | 2V = Sm. G. = 1.73 | 113 |
| | 1.456 | 1.459 | 1.340 | *Sassolite* | $B(OH)_3$ | 001 ⊥ X± | 2V = 7°. G. = 1.48 | 50 |
| | 1.459 | 1.459 | 1.431 | *Mendozite* | Sul. | X ‖ fib. | 2V = 0°. Sol. $H_2O$ | 113 |
| 1.46 | | 1.54 | 1.46 | Chrysocolla | Sil. | Z ‖ fib. | Green or brown | 411 |
| 1.462 | | 1.475 | 1.460 | *Picromerite* | Sul. | $20\bar{1}$; Y = *b* | $X\wedge c=+14°$; 2V = 48° | 112 |
| 1.464 | | 1.470 | 1.459 | *Aluminite* | Sul. | X = *c* | 2V = Lg. G. = 1.66 | 109 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.465 | Weak | | Gmelinite | Sil. | $10\bar{1}0$. $X=c$ | 2V=Sm. Ps. Hex. | 385 |
| 1.465 | .005 | | *Mordenite* | Sil. | $010 \perp Z$ | $X \wedge c=4°$. 2V=Lg. | 398 |
| 1.466 | 1.466 | 1.461 | *Ettringite* | Sul. | $10\bar{1}0$. $X=c$ | G.=1.79. Sol. HCl | 115 |
| 1.469 | 1.473 | 1.469 | Tridymite | $SiO_2$ | $Y=a$; $Z=c$ | 2V=35°. Orth. | 58 |
| 1.469 | 1.472 | 1.447 | Borax | Bor. | 100; $X=b$ | $Z \wedge c=-56°$; 2V=40° | 90 |
| 1.470 | 1.471 | 1.462 | *Paraluminite* | Sul. | X ‖ fib. | 2V=Sm. | 109 |
| 1.472 | 1.479 | 1.470 | *Boussingaultite* | Sul. | $20\bar{1}$; $Y=b$ | $X \wedge c=+5°$; 2V=51° | 113 |
| 1.472 | 1.488 | 1.454 | *Kernite* | Bor. | 001, 100 | $Z=b$. G.=1.95 | 90 |
| 1.474 | 1.485 | 1.464 | *Thenardite* | Sul. | $001 \perp Y$; $Z=a$ | 2V=83°. Sol. $H_2O$ | 96 |
| 1.474 | 1.480 | 1.473 | *Alunogen* | Sul. | $Z \wedge c=42°$ | $X=b$; 2V=Sm. | 109 |
| 1.475 | ? | ? | *Paternoite* | Bor. | Sym. Ext. in 001 | G.=2.11 | 92 |
| 1.475 | 1.476 | 1.471 | *Mordenite* | Sil. | $010 \perp Z$ | $X \wedge c=4°$; 2V=Lg. | 398 |
| 1.475 | 1.486 | 1.475 | *Laubanite* | Sil. | 110; $Z=c$? | Mon.? 2V=0° | 438 |
| 1.475 | 1.494 | 1.466 | Carnallite | Hal. | $Y=b$; $Z=a$ | 2V=70°. Deliques. | 34 |
| 1.476 | 1.502 | 1.456 | *Lansfordite* | Carb. | 001; $X=b$ | $Z \wedge c$=Sm. 2V=61° | 85 |
| 1.476 | 1.485 | 1.473 | Natrolite | Sil. | 110 at 89° | $X=c$. $Y=b$. 2V=62° | 390 |
| 1.477 | .002± | | *Ptilolite* | Sil. | $100 \perp Y$ | $X=c$. 2V=57° | 389 |
| 1.478 | 1.485 | 1.475 | *Alunogen* | Sul. | $Z \wedge c=42°$ | $X=b$. 2V=Sm. | 109 |
| 1.478 | 1.486 | 1.471 | *Melanterite* | Sul. | $Z \wedge c=-62°$ | $Y=b$. 2V=82° | 106 |
| 1.478 | 1.485 | 1.461 | *Creedite* | Sul. | 100; $Y=b$ | $Z \wedge c=42°$. 2V=64° | 121 |
| 1.478 | 1.525 | 1.478 | *Paraffin* | C, H | $Z=c$ | G.=0.9. F.=50°± | 17 |
| 1.479 | 1.480 | 1.479 | Gmelinite | Sil. | $10\bar{1}0$. $X=c$? | 2V=Sm. Ps. Hex. | 385 |
| 1.479 | 1.482 | 1.478 | *Ferrierite* | Sil. | $100 \perp X$ | $Z=c$. 2V=50° | 398 |
| 1.48 | 1.481 | 1.450 | *Goslarite* | Sul. | $010 \perp X$ | $Y=c$. 2V=46° | 104 |
| 1.480 | 1.488 | 1.475 | *Dietrichite* | Sul. | $Z \wedge c=29°±$ | $Z=b$. 2V=Lg. | 117 |
| 1.480 | 1.483 | 1.476 | *Pickeringite* | Sul. | $Z \wedge c=30°±$ | $Y=b$. 2V=Mod. | 116 |
| 1.480 | 1.502 | 1.480 | *Hatchettite* | C, H | $Z=c$ | G.=0.96. F.=80° | 18 |
| 1.480 | 1.487 | 1.475 | *Misenite* | $HKSO_4$ | $Z \wedge$ fib.=33° | 2V=Lg. | 96 |
| 1.48 | .02 | | *Vashegyite* | Phos. | Z ‖ fib. | G.=1.96 | 144 |
| 1.48 | Weak | | Phillipsite | Sil. | 100, 010 | $X=b$. $Z \wedge c=10°–30°$. 2V=70°± | 393 |
| 1.48 | Weak | | Chabazite | Sil. | $10\bar{1}1$ | 2V=Sm. Ps. Hex. | 384 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ or $N_g - N_p$ | $N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.466 | 1.466 | 1.461 | *Ettringite* | Sul. | 10$\bar{1}$0. X=$c$ | G.=1.79. Sol. HCl | 115 |
| 1.476 | | 1.485 | 1.473 | Natrolite | Sil. | 110. X=$c$ | Y=$b$. 2V=62° | 390 |
| 1.478 | | 1.525 | 1.478 | *Paraffin* | C, H | Z=$c$ | G.=0.9. F.=50°± | 17 |
| 1.48 | | Weak | | Phillipsite | Sil. | 100, 010 | X=$b$; Z∧$c$=10°–30°. 2V=70°± | 393 |
| | 1.48 | Weak | | Chabazite | Sil. | 10$\bar{1}$1 | 2V=Sm. Ps. Hex. | 384 |
| | 1.481 | 1.486 | 1.391 | *Darapskite* | Sul. | 100. 010⊥X | Z∧$c$=12°. 2V=27° | 120 |
| | 1.481 | 1.481 | 1.461 | *Hanksite* | Sul. | 0001⊥X | G.=2.56. Sol. $H_2O$ | 119 |
| 1.482 | | 1.493 | 1.480 | Natrolite | Sil. | 100 at 89° | X=$c$. Y=$b$. 2V=62° | 390 |
| | 1.482 | 1.482 | 1.478 | *Apjohnite* | Sul. | Z∧$c$=29° | Y=$b$. 2V=Sm. | 117 |
| 1.483 | | 1.488 | 1.479 | *Zn–Cu–Melanterite* | Sul. | Y∧fib.=Lg. | Z=$b$. 2V=Lg. | 106 |
| | 1.484 | 1.487 | 1.483 | *Bloedite* | Sul. | X∧$c$=43° | Y=$b$. 2V=71° | 112 |
| | 1.485 | Weak | | Chabazite | Sil. | 10$\bar{1}$1 | Z=$c$? 2V=Sm. Ps. Hex. | 384 |
| | 1.487 | 1.487 | 1.484 | *Cristobalite* | $SiO_2$ | X=$c$ | Tet.? G.=2.27 | 53 |
| | 1.487 | 1.490 | 1.483 | *Leonite* | Sul. | Z∧$c$=Sm. | Y=$b$. 2V=86°. Sol. $H_2O$ | 112 |
| | 1.487± | .001 | | **Analcite** | Sil. | Diff. | 2V=varies. Gel. HCl | 293 |
| 1.487 | | 1.496 | 1.484 | *Tamarugite* | Sul. | Y∧$c$=30°± | Z=$b$±. 2V=60° | 115 |
| 1.487 | | 1.492 | 1.487 | *Aphthitalite* | Sul. | 10$\bar{1}$0. Z=$c$ | G.=2.7. Sol. $H_2O$ | 96 |
| | 1.488 | 1.489 | 1.486 | *Bloedite* | Sul. | X∧$c$=43° | Y=$b$. 2V=71°. Sol. $H_2O$ | 112 |
| 1.488 | | 1.542 | 1.470 | *Bechilite* | Bor. | ? | 2V=62° | 92 |
| 1.488 | | 1.500 | 1.488 | *Douglasite* | Hal. | Z=$c$? | Mon.? Green | 34 |
| | 1.488 | 1.489 | 1.485 | *Vanthoffite* | Sul. | ? | 2V=84°. Mono.? | 111 |
| | 1.489 | 1.492 | 1.467 | *Morenosite* | Sul. | 010⊥X | Y=$c$. 2V=42° | 103 |
| | 1.490 | 1.490 | 1.471 | *Loewite* | Sul. | 001⊥X | G.=2.37. Sol. $H_2O$ | 111 |
| 1.490 | | 1.511 | 1.473 | *Fluellite* | Hal. | Y=$a$. Z=$c$ | 2V=85°. G.=2.17 | 33 |
| | 1.49 | .005 | | *Halotrichite* | Sul. | Z∧$c$=30°± | G.=1.9±. Sol. $H_2O$ | 116 |
| | 1.49 | 1.49 | 1.48 | *Ettringite* | Sul. | 10$\bar{1}$0. X=$c$ | G.=1.79. Sol. HCl | 115 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.492 | 1.540 | 1.412 | *Trona* | Carb. | 100. $X=b$ | $Y \wedge c=+7°$. $2V=72°$ | 96 |
| 1.493 | 1.500 | 1.493 | *Aphthitalite* | Sul. | $10\bar{1}0$. $Z=c$ | Sol. $H_2O$ | 96 |
| 1.493± | 1.495 | 1.484 | *Stellerite* | Sil. | $010 \perp Y$ | $Z=a$. $2V=44°$ | 389 |
| 1.495 | 1.500 | 1.485 | *Epidesmine* | Sil. | $100 \perp Y$ | $Z=b$. $2V=40°$ | 388 |
| 1.496 | 1.496 | 1.491 | *Levynite* | Sil. | $X=c$ | Ps. Rhom. Gel. HCl | 386 |
| 1.496 | 1.504 | 1.495 | *Struvite* | Phos. | $001 \perp X$ | $Z=b$. $2V=37°$ | 151 |
| 1.497 | 1.501 | 1.496 | Heulandite | Sil. | $010 \perp Z$ | $Y \wedge c=6°±$. $2V=34°±$ | 397 |
| 1.498 | 1.500 | 1.494 | Stilbite | Sil. | $010 \perp Y$ | $X \wedge c=5°±$. $2V=33°±$ | 395 |
| 1.500 | 1.543 | 1.418 | *Nitroglauberite* | Nit. | X ‖ elong. | $2V=61°$ | 120 |
| 1.500 | .01 | | *Aluminite?* | Sul. | Ext.Ang. Lg. | $2V$=Lg. Mon.? | 109 |
| 1.50 | 1.503 | 1.498 | *Wellsite* | Sil. | $010 \perp Z$ | $X \wedge c=4°$. $2V=39°$ | 395 |
| 1.5± | Very weak | | *Pseudomesolite* | Sil. | 110 at 90°± | $Z \wedge c=20°$. $2V$=Sm. | 399 |
| 1.500 | Weak | | *Bilinite* | Sul. | Ext. at 37° | G.=1.87 | 116 |
| 1.500 | 1.500 | 1.464 | *Thaumasite* | Sul. | $X=c$ | Hex. G.=1.87 | 119 |
| 1.501 | 1.505 | 1.499 | Heulandite | Sil. | $010 \perp Z$ | $Y \wedge c=6°±$. $2V=34°±$ | 397 |
| 1 501 | .015 | | *Didymolite* | Sil. | $010 \perp Y$ | $X \wedge c=40°$. $2V=83°±$ | 428 |
| 1.502? | 1.511 | 1.490 | **Antigorite** | Sil. | $001 \perp X$ | $2V$=Lg. Greenish: $X<Z$ | 280 |
| 1.503 | 1.545 | 1.503 | *Paraffin* | C, H | $Z=c$ | G.=0.9. F.=50°± | 17 |
| 1.503 | 1.539 | 1.500 | *Uranothallite* | Carb. | $100 \perp X$ | $2V=40°±$. Orth. | 88 |
| 1.503 | 1.510 | 1.501 | *Prosopite* | Hal. | $Z \wedge c=50°$ | $Y=b$. $2V=63°$ | 34 |
| 1.504 | 1.508 | 1.500 | Stilbite | Sil. | $010 \perp Y$ | $X \wedge c=5°±$. $2V=33°±$ | 395 |
| 1.504 | 1.520 | 1.491 | Ulexite | Bor. | $Y \wedge c=23°$ | $Z=b$. $2V$=Lg. | 93 |
| 1.505 | .0005 | | *Mesolite* | Sil. | 110, $1\bar{1}0$ | Tr. $Y \wedge c=3°±$ | 399 |
| 1.505 | 1.508 | 1.503 | *Harmotome* | Sil. | $010 \perp Z$ | $X \wedge c=62°$. $2V=43°$ | 395 |
| 1.505 | 1.516 | 1.494 | *Kainite* | Sul. | 100, 110 | $Y=b$. $X \wedge c=8°$. $2V=85°$ | 120 |
| 1.505 | 1.506 | 1.335 | Niter | $KNO_3$ | 011 at 70° | $X=c$. $Y=a$. $2V=7°$. G.=2.1 | 89 |
| 1.505 | .01 | | *Deweylite* | Sil. | Z ‖ fib. | $2V$=Sm. G.=2.3± | 261 |
| 1.506 | 1.506 | 1.344 | *Nitromagnesite* | Nit. | 110? | $2V=5°$. Mono. | 89 |
| 1.506 | .011 | | *Parasepiolite* | Sil. | Z ‖ fib. | $2V=50°$. Gel. HCl | 410 |
| 1.506 | 1.506 | 1.468 | *Thaumasite* | Sul. | $X=c$ | Hex. G.=1.87 | 119 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ (or $N_g - N_p$) | $N_p$ | Mineral | Chem. | Cleavage Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.48 | | **Weak** | | Phillipsite | Sil. | 100, 010 | X=*b*. Z∧*c*=10°–30°, 2V=70°± | 393 |
| | 1.505 | .01 | | *Deweylite* | Sil. | Z ‖ fib. | 2V=Sm. G.=2.3 | 261 |
| 1.507 | | 1.528 | 1.495 | *Bischofite* | Hal. | Y∧*c*=+10° | X=*b*. 2V=79° | 32 |
| 1.508 | | 1.545 | 1.504 | *Ussingite* | Sil. | 001, 110 | Tr. 2V=39° | 439 |
| 1.508 | | 1.509 | 1.508 | **LEUCITE** | Sil. | Poor | 2V=0°±. Ps. Isom. | 291 |
| 1.509 | | 1.575 | 1.504 | *Pirssonite* | Carb. | Y=*c*. Z=*b* | 2V=33°. G.=2.35 | 87 |
| | 1.509 | 1.509 | 1.486 | *Nocerite* | Hal. | X=*c* | Hex. G.=2.96 | 38 |
| | 1.509 | 1.509 | 1.500 | Cancrinite | Sil. | 10$\bar{1}$0. X=*c* | Efferv. Gel. HCl. | 301 |
| 1.51 | | .010 | | Phillipsite | Sil. | 010⊥X | Z∧*c*=20°±. 2V=70°± | 393 |
| 1.510 | | 1.516 | 1.504 | *Petalite* | Sil. | 001⊥Y | Z=*b*. 2V=84°. Mono. | 309 |
| 1.510 | | 1.512 | 1.502 | *Epistilbite* | Sil. | 010⊥Y | Z∧*c*=−10°. 2V=44° | 396 |
| | 1.510 | 1.521 | 1.488 | *Uranospathite* | Phos. | 001⊥X | Y=*b*. 2V=69°. Ps. Tet. | 146 |
| | 1.51 | .01± | | *Racewinite* | Sil. | None | G.=1.96± | 433 |
| | 1.51 | 1.520 | 1.495 | *Inyoite* | Bor. | 001. Y=*b* | X∧*c*=+37°. 2V=70° | 92 |
| | 1.512 | 1.512 | 1.487 | *Nocerite* | Hal. | X=*c* | Hex. G.=2.96 | 38 |
| 1.512 | | 1.523 | 1.510 | *Brewsterite* | Sil. | 010⊥Z | X∧*c*=+22°. 2V=65° | 397 |
| 1.512 | | 1.522 | 1.508 | **Chrysotile?** | Sil. | Z ‖ fib. | Y=*b*. 2V=Lg. | 260 |
| 1.512 | | 1.524 | 1.505 | *Flagstaffite* | H, C, O | Y=*b*. Z=*a* | 2V=77°. G.=1.1 | 88 |
| | 1.512 | 1.512 | 1.498 | *Hydrotalcite* | Carb. | 0001⊥X | Efferv. HCl. G.=2.06 | 87 |
| 1.513 | | 1.518 | 1.512 | Thomsonite | Sil. | 010⊥Z | Y=*c*. 2V=54°± | 387 |
| | 1.514 | 1.514 | 1.509 | Carnegieite | Sil. | ? | 2V=13°±. Tr. | 299 |
| 1.515 | | 1.520 | 1.514 | *Gonnardite* | Sil. | Z ‖ fib. | 2V=52°. Gel. HCl | 387 |
| 1.515 | | 1.54 | 1.515 | *Ozocerite* | H, C | ? | 2V=0°±. Burns | 18 |
| | 1.516 | 1.523 | 1.443 | *Gaylussite* | Carb. | 110 at 69° | X=*b*. Z∧*c*=−14°. 2V=34° | 87 |
| | 1.517 | 1.518 | 1.501 | *Syngenite* | Sul. | 110, 100 | Z=*b*. Y∧*c*=3°. 2V=28° | 111 |
| 1.517 | | 1.533 | 1.514 | *Newberyite* | Phos. | 010⊥Y | Z=*c*. 2V=45° | 123 |
| 1.518 | | 1.561 | 1.518 | *Fibroferrite* | Sul. | Z ‖ fib. | 2V=0°. Yellow; X<Z | 109 |
| 1.518 | | 1.533 | 1.516 | *Felsöbanyite* | Sul. | 001⊥Z | 2V=48°. G.=2.33 | 109 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.518 | 1.522 | 1.518 | *Leifite* | Sil. | 10$\bar{1}$0 | Inclusions. G. = 2.57 | 429 |
| 1.519± | Very weak | | *Davyne* | Sil. | 10$\bar{1}$0 | Efferv. Gel. HCl | 301 |
| 1.519 | 1.520 | 1.512 | Scolecite | Sil. | 110 at 90°± | $X \wedge c = +16°$. Z = b. 2V = 36° | 390 |
| 1.52 | .03 | | *Hautefeuillite* | Phos. | 010 ⊥ Y | $Z \wedge a = 45°$. 2V = 45° | 125 |
| 1.52 | 1.543 | 1.510 | *Bobierrite* | Phos. | 010 ⊥ X | $Z \wedge c = +29°$. 2V = 71° | 125 |
| 1.52 | 1.561 | 1.509 | *Larderellite* | Bor. | 001. X = *b* | $Y \wedge a$ = Sm. 2V = 60° | 91 |
| 1.52 | Strong | | *Zebedassite* | Sil. | Z ∥ fib. | G. = 2.19. Gel. HCl | 432 |
| 1.52 | 1.523 | 1.516 | **MICROCLINE** | Sil. | 001, 010 | 2V = 83°±. G. = 2.55 | 364 |
| 1.52± | 1.525 | 1.515 | Sepiolite | Sil. | Z ∥ fib. | 2V = 30°±. G. = 2.0 | 410 |
| 1.52 | Weak | | *Chlorocalcite* | $KCaCl_3$ | 001, 110 | Ps. Isom. Orth.? | 33 |
| 1.521 | 1.529 | 1.521 | *Microsommite* | Sil. | 10$\bar{1}$0. Z = *c* | G. = 2.45. Gel. HCl | 301 |
| 1.522 | 1.527 | 1.522 | *Natrodavyne* | Sil. | 10$\bar{1}$0. Z = *c* | Efferv. Gel. HCl | 301 |
| 1.522 | 1.522 | 1.513 | *Tachyhydrite* | Hal. | 10$\bar{1}$1. X = *c* | Deliques. G. = 1.67? | 32 |
| 1.522 | 1.524 | 1.518 | **ORTHOCLASE** | Sil. | 001, 010 | $X \wedge a = 6°$. Z = *b*. 2V = 70°± | 361 |
| 1.523 | 1.530 | 1.521 | **Gypsum** | Sul. | 010 ⊥ Y | $Z \wedge c = +52°$. 2V = 58° | 104 |
| 1.523 | 1.588 | 1.518 | *Hatchettite* | $C_{38}H_{78}$ | One ⊥ Z | 2V = Sm. | 18 |
| 1.523 | 1.532 | 1.518 | *Gyrolite* | Sil. | 001 ⊥ X | 2V = ? Sol. HCl | 408 |
| 1.524 | 1.524 | 1.502 | Cancrinite | Sil. | 10$\bar{1}$0. X = *c* | Efferv. Gel. HCl | 301 |
| 1.524 | 1.525 | 1.513 | *Laumontite* | Sil. | 010, 110 | Y = *b*. $Z \wedge c = -30°$±. 2V = 53°± | 391 |
| 1.524 | 1.528 | 1.520 | *Searlesite* | Sil. | 100. Z = *b* | $X \wedge c = 30°$. 2V = Lg. | 423 |
| 1.524± | 1.524 | 1.517 | **SANIDINE** | Sil. | 001, 010 | $X \wedge a = 6°$±. 2V = Sm. | 361 |
| 1.525 | .01 | | *Deweylite* | Sil. | Z ∥ fib. | 2V = Sm. G. = 2.3 | 261 |
| 1.525 | 1.532 | 1.523 | *Chalcoalumite* | Sul. | Several | Tr.? 2V = Lg. Green | 117 |
| 1.525 | 1.586 | 1.508 | *Sideronatrite* | Sul. | 100 ⊥ X | Z = *c*. 2V = 58°. | 115 |
| 1.526 | 1.550 | 1.508 | *Kaliborite* | Bor. | 100, 001 | X = *b*. $Z \wedge c = +65°$. 2V = 81° | 94 |
| 1.526 | 1.529 | 1.522 | **MICROCLINE** | Sil. | 001, 010 | Z = *b*±. 2V = 83°± | 364 |
| 1.526 | 1.528 | 1.522 | **ORTHOCLASE** | Sil. | 001, 010 | $X \wedge a = 6°$. Z = *b*. 2V = 70°± | 361 |
| 1.526 | 1.534 | 1.513 | *Fe-Cu-Chalcanthite* | Sul. | ? | 2V = 60°± | 107 |
| 1.527 | 1.545 | 1.523 | *Hydromagnesite* | Carb. | 010 ⊥ Z | $Y \wedge c = -43°$. 2V = Mod. | 85 |
| 1.528± | 1.529 | 1.523 | **ANORTHOCLASE** | Sil. | 001, 010 | $X \wedge a = 9°$±. 2V = 50°± | 366 |
| 1.528 | 1.575 | 1.506 | *Copiapite* | Sul. | 001 ⊥ X. Y = *b* | 2V = 60°±. X = green, Z = yellow | 108 |
| 1.529 | 1.536 | 1.525 | **ALBITE** | Sil. | 001, 010 | $Z \wedge b = 12°$±. 2V = 70° | 369 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g-N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.513 | | 1.518 | 1.512 | Thomsonite | Sil. | 010⊥Z | Y=*c*. 2V=54± | 387 |
| 1.518 | | 1.561 | 1.518 | *Fibroferrite* | Sul. | Z ∥ fib. | 2V=0°. Yellow. X<Z | 109 |
| | 1.524 | 1.528 | 1.520 | *Searlesite* | Sil. | 100. Z=*b* | X∧*c*=30°. 2V=Lg. | 423 |
| | 1.526 | 1.534 | 1.513 | *Fe-Cu-Chalcanthite* | Sul. | ? | 2V=60°± | 107 |
| 1.527 | | 1.545 | 1.523 | *Hydromagnesite* | Carb. | 010⊥Z | Y∧*c*=43°. 2V=Mod. | 85 |
| 1.528 | | 1.575 | 1.506 | *Copiapite* | Sul. | 001⊥X; Y=*b* | 2V=60°±. X=green, Z=yellow | 108 |
| 1.529 | | 1.536 | 1.525 | **ALBITE** | Sil. | 001, 010 | Z∧*b*=12°±. 2V=70° | 369 |
| 1.530 | | 1.540 | 1.527 | *Hydromagnesite* | Carb. | 010⊥Z | Y∧*c*=43°. 2V=Mod. | 85 |
| 1.530 | | 1.544 | 1.522 | *Tavistockite* | Phos. | 100⊥Y | Z=*c*. 2V=74° | 154 |
| 1.530 | | 1.550 | 1.525 | *Wapplerite* | Arsen. | 010⊥Z± | 2V=35°. G.=2.48 | 124 |
| | 1.530 | 1.538 | 1.511 | Chalcanthite | Sul. | Poor | Tr. 2V=56° | 106 |
| | 1.530 | 1.542 | 1.518 | *Minasragrite* | Sul. | 010, 110 | Ext. Ang.=12°. Blue; X>Z | 110 |
| 1.53± | | | .005± | Marialite | Sil. | 110 at 90° | 2V=0°. G.=2.6 | 296 |
| | 1.531 | 1.531 | 1.510 | *Bechilite* | Bor. | ? | 2V=0° | 92 |
| | 1.531 | 1.534 | 1.528 | **Hyalophane** | Sil. | 001, 010 | X∧*a*=+2°. 2V=74° | 260 |
| 1.531 | | 1.583 | 1.518 | Kieserite | Sul. | $11\bar{1}$, $11\bar{3}$ | Z∧*c*+76°. 2V=55° | 104 |
| 1.532 | | 1.542 | 1.530 | Thomsonite | Sil. | 010⊥Z | 2V=54°. Gel. HCl | 387 |
| | 1.532 | 1.532 | 1.529 | *Milarite* | Sil. | X=*c* | 2V=Sm. Ps. Hex. | 429 |
| | 1.532 | 1.536 | 1.515 | *Glauberite* | Sul. | 001. Z=*b* | X∧*c*=+37°. 2V=Sm. | 110 |
| | 1.532 | 1.532 | 1.527 | *Kaliophilite* | Sil. | X=*c* | G.=2.56. Gel. HCl | 300 |
| | 1.533 | 1.535 | 1.513 | *Searlesite* | Sil. | 100. Z=*b* | X∧*c*=30°. 2V=Mod.? | 423 |
| 1.533 | | 1.545 | 1.530 | *Echellite* | Sil. | 010⊥*b* | Y=*c*. 2V=50° | 389 |
| | 1.533 | 1.533 | 1.526 | Chalcedonite | $SiO_2$ | Fibers | G.=2.6 | 57 |
| 1.534 | | 1.575 | 1.533 | *Fibroferrite* | Sul. | Z ∥ fib. | 2V=0°±. Yellow; X<Z | 109 |
| 1.534 | | 1.552 | 1.525 | Wavellite | Phos. | 010⊥X | Z=*c*. 2V=72° | 144 |
| 1.534 | | 1.565 | 1.517 | *Hydroboracite* | Bor. | 100, 010 | Z∧*c*=31°. 2V=Lg. | 92 |
| | 1.534 | 1.557 | 1.489 | *Artinite* | Carb. | Y ∥ fib. | 2V=71°. G.=2.03 | 84 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.534 | 1.534 | 1.514 | *Zincaluminite* | Sul. | X=*c* | G.=2.26 | 115 |
| 1.535 | 1.586 | 1.523 | Kieserite | Sul. | $11\bar{1}$, $11\bar{3}$ | Z∧*c*=+76°. 2V=55° | 104 |
| 1.535 | 1.582 | 1.530 | *Quetenite* | Sul. | 110 | 2V=34°. Brown; X<Z | 116 |
| 1.535 | 1.535 | 1.537 | Apophyllite | Sil. | 001⊥Z | Abn. int. colors | 262 |
| 1.535 | 1.536 | 1.528 | *Kaliophilite?* | Sil. | ? | 2V=39°. Twin. | 300 |
| 1.535 | 1.560 | 1.500 | *Meyerhofferite* | Bor. | 010 | 2V=79°. G.=2.12 | 93 |
| 1.536 | Weak | | *Brugnatellite* | Carb. | 0001⊥X | Efferv. HCl | 87 |
| 1.536 | 1.541 | 1.532 | **ALBITE** | Sil. | 001, 010 | Z∧*b*=15°±. 2V=75° | 369 |
| 1.536 | .001± | | *Milarite* | Sil. | X=*c* | 2V=0°±. G.=2.57 | 429 |
| 1.536 | 1.543 | 1.517 | *Fe-Cu-Chalcanthite* | Sul. | ? | 2V=60°±. Sol. $H_2O$ | 107 |
| 1.536 | 1.539 | 1.532 | **Cordierite** | Sil. | 010⊥Z | X=*c*. 2V=60°±. Twins | 307 |
| 1.536 | 1.541 | 1.532 | **OLIGOCLASE** | Sil. | 001, 010 | Z=*b*±. 2V=90°± | 371 |
| 1.536 | 1.536 | 1.532 | **NEPHELITE** | Sil. | X=*c* | G.=2.6. Gel. HCl | 298 |
| 1.537 | 1.537 | 1.533 | *Kaliophilite* | Sil. | X=*c* | G.=2.56. Gel. HCl | 300 |
| 1.537 | 1.545 | 1.528 | ***Siderotile*** | Sul. | ? | 2V=Mod. Sol. $H_2O$ | 107 |
| 1.537± | 1.541 | 1.530 | *Okenite* | Sil. | 010 | 2V=Lg. Gel. HCl | 413 |
| 1.539 | 1.539 | 1.532 | Chalcedonite | $SiO_2$ | Fibers | G.=2.6 | 57 |
| 1.539 | 1.546 | 1.516 | Chalcanthite | Sul. | Poor | 2V=56°. Sol. $H_2O$ | 106 |
| 1.539 | 1.539 | 1.511 | *Mellite* | Al, C, O, H | Poor | Tet. G.=1.6 | 88 |
| 1.540 | 1.540 | 1.510 | *Brugnatellite* | Carb. | 0001⊥X | Efferv. HCl | 87 |
| 1.54± | 1.548 | 1.531 | *Gismondite* | Sil. | 101. X=*b* | Z=*a*±. 2V=84°± | 373 |
| 1.54 | 1.545 | 1.520 | *Lueneburgite* | Phos. | 110 at 73° | X∧*c*=45°. Y=*b*. 2V=Mod. | 161 |
| 1.540 | 1.544 | 1.527 | ***Sulfoborite*** | Sul. | 110 at 64° | X=*c*. Y=*b*. 2V=70° | 120 |
| 1.540 | .01 | | *Gyrolite* | Sil. | 0001⊥X | Also biax. Sol. HCl | 408 |
| 1.542 | 1.542 | 1.516 | ***Stichtite*** | Carb. | 0001⊥X | Efferv. HCl. Lilac | 87 |
| 1.542 | 1.596 | 1.466 | *Dawsonite* | Carb. | 110 at 66° | X=*a*. Y=*c*. 2V=77°. Efferv. HCl | 87 |
| 1.543 | Very weak | | Apophyllite | Sil. | 001⊥X | Abn. int. colors | 262 |
| 1.543± | 1.555 | 1.542 | **Chrysotile** | Sil. | Z ∥ fib. | Y=*b*. 2V=32°± | 260 |
| 1.544 | 1.553 | 1.544 | **QUARTZ** | $SiO_2$ | Z=*c* | G.=2.65. Sol. HF | 54 |
| 1.544 | 1.546 | 1.544 | *Epididymite* | Sil. | 001⊥Y; 010⊥Z | 2V=22°. Ps. Hex. twin. | 418 |
| 1.545 | 1.547 | 1.542 | **Hyalophane** | Sil. | 001, 010 | Z=*b*. 2V=78° | 360 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | | − | $N_g$ or $N_g-N_p$ | $N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|---|
| 1.528 | | | 1.575 | 1.506 | *Copiapite* | Sul. | 001 ⊥ X; Y = *b* | 2V = 60° ±. X = green, Z = yellow | 108 |
| | | 1.53 | .005 ± | | Marialite | Sil. | 110 | 2V = 0°. G. = 2.6 | 296 |
| | | 1.536 | 1.539 | 1.532 | **Cordierite** | Sil. | 010 ⊥ Z; X = *c* | 2V = 60° ±. Twins | 307 |
| | 1.536 | | 1.541 | 1.532 | **OLIGOCLASE** | Sil. | 001, 010 | Z = *b* ±. 2V = 90° ± | 371 |
| | | 1.536 | 1.536 | 1.532 | **NEPHELITE** | Sil. | X = *c* | G. = 2.6. Gel. HCl | 298 |
| | | 1.540 | .01 | | *Gyrolite* | Sil. | 0001 ⊥ X | Also biax. Sol. HCl | 408 |
| | | 1.545 | Weak | | *Eucryptite* | Sil. | 0001 ⊥ X | Hex. G. = 2.67 | 300 |
| | | 1.545 | 1.545 | 1.503 | *Pholidolite* | Sil. | 001 ⊥ X | 2V = 10° ±. G. = 2.41 | 435 |
| | | 1.545 | 1.545 | 1.525 | Vermiculite * | Sil. | 001 ⊥ X | 2V = Sm. Yellow; X < Y | 434 |
| 1.546 | | | 1.546 | 1.540 | Marialite | Sil. | 110 at 90° | G. = 2.6 | 296 |
| 1.546 | | | 1.551 | 1.539 | *Brushite* | Phos. | 010 ⊥ Z | X ∧ *c* = −72°. 2V = 84° | 123 |
| 1.546 | | | 1.551 | 1.545 | *Eudidymite* | Sil. | 001. Y = *b* | Z ∧ *c* = 59°. 2V = 30° | 418 |
| | | 1.546 | 1.546 | 1.540 | Dipyre | Sil. | 100 | Inclusions common | 296 |
| | | 1.547 | 1.595 | 1.438 | *Oxammite* | Oxal. | X = *c*. Y = *a* | 2V = 62° | 89 |
| 1.547 | | | 1.564 | 1.541 | *Voglite* | Carb. | One ⊥ X ± | 2V = 60°. Efferv. HCl | 88 |
| | | 1.548 | 1.548 | 1.540 | *Gyrolite* | Sil. | 0001 ⊥ X | Also biax. Sol. HCl | 408 |
| | | 1.548 | 1.549 | 1.535 | *Centrallasite* | Sil. | One ⊥ X | 2V = Sm. Fibers | 409 |
| | | 1.548 | 1.550 | 1.530 | *Co-Chalcanthite* | Sul. | Poor | 2V = Mod. Pink | 107 |
| 1.548 | | | 1.572 | 1.544 | *Botryogen* | Sul. | 010 ⊥ X | 2V = 41°. X = yellow, Z = red | 116 |
| | 1.549 | | 1.553 | 1.545 | **OLIGOCLASE** | Sil. | 001, 010 | 2V = 90° ±. Lam. twin | 371 |
| | | 1.549 | 1.549 | 1.544 | **NEPHELITE** | Sil. | Poor | Hex. G. = 2.6. Gel. HCl | 298 |
| | | 1.549 | 1.554 | 1.539 | *Edingtonite* | Sil. | 110 at 90° ± | X = *c*. Y = *b*. 2V = 50° ± | 389 |
| | 1.549 | | 1.553 | 1.545 | **ANDESINE** | Sil. | 001, 010 | 2V = 90° ±. Lam. twin. | 372 |
| 1.550 | | | 1.600 | 1.540 | *Copiapite* | Sul. | 001 ⊥ X. Y = *b* | 2V = 60° ±. X = green, Z = yellow | 108 |
| 1.550 | | | 1.635 | 1.533 | *Rhomboclase* | Sul. | 001 ⊥ X. Y = *a* | 2V = Sm. X = red, Z = yellow | 108 |
| | 1.55 | | .02 | | *Zepharovichite* | Phos. | Z ‖ fib. | G. = 2.37. Sol. HCl | 141 |
| | | 1.55 | .01? | | *Pyroaurite* | Carb. | 0001 ⊥ X | Efferv. HCl | 87 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.55 | 1.55 | 1.53 | *Ascharite* | Bor. | X ‖ fib. | 2V=Sm. | 92 |
| 1.55 | .01± | | **Antigorite** | Sil. | 001⊥X | X=yellow, Z=green | 280 |
| 1.55 | 1.55 | 1.53 | **Lepidolite** | Sil. | 001⊥X | Z=*b*. 2V=40°±. Pink | 270 |
| 1.552 | 1.557 | 1.552 | *Coquimbite* | Sul. | Poor | Z=*c*. Rhom. | 107 |
| 1.553 | 1.584 | 1.553 | *Narsarsukite* | Sil. | 110 at 90° | Z=*c*. Tet. Yellow; X<Z | 429 |
| 1.554 | .016 | | *Grothine* | Sil. | X=*b*. Y=*c* | 2V=Mod. | 432 |
| 1.554 | 1.576 | 1.554 | Gibbsite | Ox. | 001 | 2V=Sm. G.=2.35 | 48 |
| 1.555 | Mod. | | *Soumansite* | Phos. | ? | Tet. Also biax. | 151 |
| 1.555 | 1.562 | 1.551 | *Vauxite* | Phos. | Z⊥010± | 2E=32°. Blue: X<Y | 157 |
| 1.555 | 1.650 | 1.490 | *Whewellite* | Oxal. | 001; 010⊥X | Z∧*c*=+29°. 2V=84° | 89 |
| 1.555 | .01± | | *Saponite* | Sil. | One⊥X | 2V=0°. G.=2.26 | 437 |
| 1.555 | .01 | | *Morinite* | Phos. | 100. Y=*b* | X∧*c*=+30°. 2E=40° | 158 |
| 1.556 | 1.559 | 1.552 | *Miloschite* | Sil. | 001⊥X± | 2V=90°±. G.=2.1 | 416 |
| 1.557 | 1.562 | 1.555 | **ANDESINE** | Sil. | 001, 010 | 2V=90°±. Lam. twin. | 372 |
| 1.557 | 1.562 | 1.555 | **LABRADORITE** | Sil. | 001, 010 | 2V=80°±. Lam. twin. | 374 |
| 1.558 | 1.573 | 1.554 | *Paravauxite* | Phos. | 010. Tric. | 2V=35°. Sol. HCl | 157 |
| 1.558 | 1.582 | 1.551 | *Metavariscite* | Phos. | X=*a*. Y=*b* | 2V=55°. Sol. HCl | 141 |
| 1.558 | 1.562 | 1.552 | *Beryllonite* | Phos. | 001⊥X | 2V=68°. Ps. Hex. twin. | 149 |
| 1.559 | 1.627 | 1.559 | *Ferrinatrite* | Sul. | 10$\bar{1}$0, Z=*c* | G.=2.56. Sol. $H_2O$ | 114 |
| 1.56± | .04 | | Magnesiopectolite | Sil. | X ‖ fib. | G.=2.69 | 420 |
| 1.560 | 1.560 | 1.495 | *Trudellite* | Sul. | X=*c* | G.=1.93 | 119 |
| 1.56 | Very weak | | **Penninite** | Sil. | 001⊥X± | 2V=Sm. Green: X<Z | 281 |
| 1.56 | .03± | | **Zinnwaldite** | Sil. | 001⊥X± | Z=*b*. 2V=35°±. Brown: X<Z | 270 |
| 1.56 | Weak | | *Calcioferrite* | Phos | 001⊥X± | 2V=0°±. Yellow, green | 156 |
| 1.56 | 1.56 | 1.53 | *Nepouite* | Sil. | 001⊥X± | 2V=0°±. X=green, Z=yellow | 279 |
| 1.56 | .02± | | *Faratsihite* | Sil. | 001⊥X± | Yellow | 416 |
| 1.561 | 1.692 | 1.494 | *Humboldtite* | Oxal. | 110 at 75°. Y=*b* | Z=c. 2V=Lg. X=green, Z=yel. | 88 |
| 1.562 | 1.57 | 1.552 | **Cordierite** | Sil. | 010⊥Z | X=*c*. 2V=60°±. Ps. Hex. | 307 |
| 1.562 | 1.567 | 1.548 | Polyhalite | Sul. | 100. Tric. | Lam. twin. G.=2.78 | 113 |
| 1.564 | .019 | | Brucite | Ox. | 0001⊥Z | Rhom. G.=2.4 | 42 |

* E. V. Shannon; *Am. Jour. Sci.* CCXV, 1928, p. 20.

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | − | $N_g$ | $N_p$ (or $N_g - N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.545 | 1.545 | 1.525 | Vermiculite | Sil. | 001⊥X | 2V=Sm. Yellow: X<Y | 434 |
| | 1.546 | 1.546 | 1.540 | Dipyre | Sil. | 100 | Inclusions common | 296 |
| | 1.55 | .01± | | **Antigorite** | Sil. | 001⊥X | X=yellow, Z=green | 280 |
| | 1.55 | 1.55 | 1.53 | **Lepidolite** | Sil. | 001⊥X | Z=*b*. 2V=40°±. Pink | 270 |
| 1.554 | | 1.576 | 1.554 | Gibbsite | Ox. | 001 | 2V=Sm. G.=2.35 | 48 |
| 1.557 | | 1.562 | 1.555 | **LABRADORITE** | Sil. | 001, 010 | 2V=80°±. Lam. Twin. | 374 |
| | 1.56 | Very weak | | **Penninite** | Sil. | 001⊥X± | 2V=Sm. Green: X<Z | 281 |
| | 1.56 | .03± | | **Zinnwaldite** | Sil. | 001⊥X± | Z=*b*. 2V=35°±. Brown: X<Z | 270 |
| | 1.56 | Weak | | *Calcioferrite* | Phos. | 001⊥X± | 2V=0°±. Yellow, green | 156 |
| | 1.56 | 1.56 | 1.53 | *Nepouite* | Sil. | 001⊥X± | 2V=0°±. X=green, Z=yellow | 279 |
| | 1.564 | 1.565 | 1.535 | **Phlogopite** | Sil. | 001⊥X | Y=*b*. 2V=10°±. G.=2.75 | 272 |
| | 1.565 | .025± | | **Lepidolite** | Sil. | 001⊥X | 2V=Sm. Pink | 270 |
| 1.565 | | 1.574 | 1.560 | *Elpidite* | Sil. | 110 at 54° | Y=*b*. Z=*a*. 2V=75°± | 400 |
| 1.565 | | 1.575 | 1.565 | *Pinnoite* | Bor. | Z=*c* | Tet. G.=2.29 | 92 |
| | 1.565 | 1.565 | 1.559 | *Reyerite* | Sil. | 001⊥X | Rhom. G.=2.52 | 408 |
| | 1.565 | 1.567 | 1.561 | **Kaolinite** | Sil. | 001⊥X± | Z=*b*. 2V=60°. Ps. Hex. | 264 |
| | 1.565 | 1.565 | 1.560 | *Zeophyllite* | Sil. | 001⊥X | Also biax. | 408 |
| | 1.565 | .01 | | *Pyroaurite* | Carb. | 0001⊥X | Efferv. HCl. Red: X<Z | 87 |
| | 1.565 | Weak | | *Zaratite* | Carb. | Paral. Ext. | Efferv. HCl. Green | 85 |
| | 1.565 | 1.570 | 1.550 | *Variscite* | Phos. | ? | G.=2.54. Sol. HCl | 140 |
| 1.567 | | 1.589 | 1.567 | Gibbsite | Ox. | 001 | 2V=Sm. G.=2.35 | 48 |
| 1.567 | | 1.572 | 1.564 | **LABRADORITE** | Sil. | 001, 010 | 2V=80°±. Lam. twin. | 374 |
| 1.567 | | 1.590 | 1.563 | *Norbergite* | Sil. | ? | 2V=49°. G.=3.14. Gel. HCl | 196 |
| | 1.567 | 1.572 | 1.564 | **BYTOWNITE** | Sil. | 001, 010 | 2V=80°±. Lam. twin. | 376 |
| 1.568 | | .01 | | *Natroalunite* | Sul. | 0001⊥Z | G.=2.6 | 114 |
| 1.568 | | 1.580 | 1.565 | *Isoclasite* | Phos. | 010⊥Y | Z∧*c*=Sm. 2V=50°± | 137 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.568 | 1.568 | 1.564 | Beryl | Sil. | $X=c$ | Also biax. Pneumat. | 212 |
| 1.569 | 1.572 | 1.485 | *Griffithite* | Sil. | 001⊥X | 2V=Sm. X=yellow, Z=green | 434 |
| 1.570 | 1.570 | 1.545 | Dipyre | Sil. | 100. $X=c$ | Tet. Incl. common | 296 |
| 1.57± | 1.576 | 1.568 | *Jurupaite* | Sil. | Z∧fib.=31° | G.=2.75. Sol. HCl | 412 |
| 1.57± | 1.585 | 1.555 | *Tengerite* | Carb. | X ∥ fib. | 2V=Lg. | 86 |
| 1.57 | .026± | | *Xylotile* | Sil. | Z ∥ fib. | 2V=Sm. Yellow: X<Z | 261 |
| 1.570 | 1.582 | 1.569 | *Wagnerite* | Phos. | $Y=b$ | $Z\wedge c=22°$. 2V=26° | 134 |
| 1.57 | .016± | | *Barrandite* | Phos. | Z ∥ fib. | 2V=Mod. G.=2.6 | 140 |
| 1.57 | Very weak | | **Penninite** | Sil. | 001⊥Z | 2V=Sm. Green: X<Z | 281 |
| 1.57 | .006± | | **Clinochlore** | Sil. | 001⊥Z | 2V=Sm. Green: X>Z | 283 |
| 1.57 | 1.570 | 1.545 | Mizzonite | Sil. | 100. $X=c$ | Tet. Incl. common | 297 |
| 1.571 | 1.596 | 1.563 | *Hoernesite* | Phos. | 100. $X=b$ | $Z\wedge c=+32°$. 2V=60° | 125 |
| 1.571 | 1.583 | 1.524 | *Roemerite* | Sul. | 001? | 2V=51°. Brown: X=Z<Y | 117 |
| 1.572 | 1.592 | 1.572 | *Alunite* | Sul. | 0001⊥Z | Rhom. G.=2.60 | 113 |
| 1.572 | 1.575 | 1.555 | *Hannayite* | Phos. | 010⊥X | $Y\wedge c=33°$. 2V=42° | 151 |
| 1.574 | 1.580 | 1.558 | *Bassetite* | Phos. | 010⊥X | $Z\wedge c=4°$. 2E=110° | 146 |
| 1.575 | .01 | | *Loewigite* | Sul. | 0001? | G.=2.58 | 114 |
| 1.575 | 1.575 | 1.547 | *Errite* | Sil. | 0001⊥X | Brown; pleo. | 407 |
| 1.575 | 1.577 | 1.553 | *Autunite* | Phos. | 001⊥X. $Y=b$ | 2V=33°. Yellow: X<Z | 146 |
| 1.575 | .04± | | **Talc** | Sil. | 001⊥X. $Z=b$ | 2V=20°±. Insol. | 262 |
| 1.576 | 1.614 | 1.570 | Anhydrite | Sul. | 001⊥X | 010⊥Y. 2V=42° | 98 |
| 1.576 | 1.588 | 1.574 | *Augelite* | Phos. | 110 at 67° | $Y=b$. $Z\wedge c=-34°$. 2V=51° | 143 |
| 1.576 | 1.588 | 1.562 | *Spherite* | Phos. | Fibers | 2V=Lg. | 144 |
| 1.576 | 1.576 | 1.546 | *Parsettensite* | Sil. | 0001⊥X | Yellow: X>Z | 407 |
| 1.578 | 1.582 | 1.571 | **BYTOWNITE** | Sil. | 001, 010 | 2V=80°±. Lam. twin. | 376 |
| 1.578 | 1.60 | 1.54 | *Fichtelite* | $C_{18}H_{32}$ | 001. $Y=b$ | $Z\wedge c=+13°$. 2V=87° | 18 |
| 1.578 | 1.601 | 1.544 | *Kroehnkite* | Sul. | 010⊥Y | $X\wedge c=-49°$; 2V=79°. Blue | 112 |
| 1.578 | 1.582 | 1.571 | **ANORTHITE** | Sil. | 001, 010 | 2V=80°±. Lam. twin. | 378 |
| 1.579 | 1.583 | 1.578 | *Bavenite* | Sil. | 010⊥Z | $X\wedge a=2°$. 2V=47° | 438 |
| 1.58 | .016± | | *Barrandite* | Phos. | Z ∥ fib. | 2V=Mod. | 140 |
| 1.58 | Weak | | *Calcioferrite* | Phos. | 001⊥X± | 2V=0°±. Yellow, green | 156 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g-N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.545 | 1.545 | 1.525 | Vermiculite | Sil. | 001⊥X | 2V=Sm. Yellow: X<Y | 434 |
| | 1.55 | | .01± | **Antigorite** | Sil. | 001⊥X | X=yellow, Z=green | 280 |
| | 1.56 | | Very weak | **Penninite** | Sil. | 001⊥X | 2V=Sm. Green: X<Z | 281 |
| | 1.56 | | .03± | **Zinnwaldite** | Sil. | 001⊥X± | Z=*b*. 2V=35°±. Brown: X<Z | 270 |
| | 1.56 | 1.56 | 1.53 | *Nepouite* | Sil. | 001⊥X± | 2V=0°±. X=green, Z=yellow | 279 |
| | 1.564 | 1.565 | 1.535 | **Phlogopite** | Sil. | 001⊥X± | Y=*b*. 2V=10°±. G.=2.75 | 272 |
| | 1.565 | 1.570 | 1.550 | *Variscite* | Phos. | ? | G.=2.54. Sol. HCl | 140 |
| | 1.568 | 1.568 | 1.564 | Beryl | Sil. | X=*c* | Also biax. Pneumat. | 212 |
| | 1.57 | 1.570 | 1.545 | Mizzonite | Sil. | 100. X=*c* | Tet. Incl. common | 297 |
| 1.57 | | | Very weak | **Penninite** | Sil. | 001⊥Z | 2V=Sm. Green: X>Z | 281 |
| 1.57 | | | .006± | **Clinochlore** | Sil. | 001⊥Z | 2V=Sm. Green: X>Z | 379 |
| | 1.575 | 1.577 | 1.553 | *Autunite* | Phos. | 001⊥X. Y=*b* | 2V=33°. Yellow: X<Z | 146 |
| | 1.575 | | .04± | **Talc** | Sil. | 001⊥X. Z=*b* | 2V=20°±. Insol. | 262 |
| | 1.578 | 1.582 | 1.571 | **ANORTHITE** | Sil. | 001, 010 | 2V=80°±. Lam. twin. | 378 |
| 1.58 | | 1.615 | 1.540 | *Hambergite* | Bor. | 010⊥Y. X=*a* | G.=2.35. H.=7.5 | 91 |
| | 1.58 | | .01± | **Antigorite** | Sil. | 001⊥X | X=yellow, Z=green | 280 |
| | 1.58 | 1.59 | 1.55 | *Jezekite* | Phos. | 100. Y=*b* | X∧*c*=+29°. 2V=Mod. | 158 |
| | 1.58 | 1.582 | 1.562 | *Canbyite* | Sil. | One ⊥ Z | 2V=Sm. | 415 |
| 1.580 | | 1.588 | 1.580 | *Ceruleolactite* | Phos. | Z ∥ fib. | 2V=0°. Sol. HCl | 143 |
| 1.58 | | 1.597 | 1.576 | *Cookeite* | Sil. | 001⊥Z | 2V=40°±. G.=2.67 | 435 |
| 1.58 | | | .015± | Amesite | Sil. | 001⊥Z | 2V=Sm. Ps. Hex. | 285 |
| 1.580 | | 1.640 | 1.580 | *Cacoxenite* | Phos. | Z=*c* | 2V=0°. Yellow: X<Z | 143 |
| 1.58 | | | .01± | Corundophilite | Sil. | 001⊥X | 2V=Sm. Green: X<Z | 283 |
| | 1 582 | 1.587 | 1.56 | *Uranospinite* | Phos. | 001⊥X | 2V=46°. Also biax. Yel: X<Z | 147 |
| | 1.582± | | .008 | *Hopeite* | Phos. | 100⊥Z? | 2V=0°±. G.=3 | 124 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.582 | 1.588 | 1.552 | **MUSCOVITE** | Sil. | 001⊥X | $Z=b$. 2V=47° | 267 |
| 1.583 | 1.602 | 1.583 | *Alumianite* | Sul. | ? | Rhom. Sol. HCl | 107 |
| 1.583 | 1.593 | 1.583 | *Xonotlite* | Sil. | Z ‖ fib. | $X=b$. 2V=Sm. | 409 |
| 1.584 | 1.589 | 1.576 | **ANORTHITE** | Sil. | 001, 010 | 2V=80°±. Lam. twin. | 378 |
| 1.585 | 1.656 | 1.585 | *Cacoxenite* | Phos. | $Z=c$ | 2V=0°. Yellow: X<Z | 143 |
| 1.585 | .01 | | *Natroalunite* | Sul. | 001⊥Z | G.=2.6 | 114 |
| 1.585 | 1.585 | 1.576 | *Metazeunerite* | Phos. | 001⊥X | 2V=0°±. Green: X<Z | 146 |
| 1.585 | 1.585 | 1.337 | *Nitratite* | $NaNO_3$ | $10\bar{1}1$. $X=c$ | Rhom. G.=2.27. Sol. $H_2O$ | 89 |
| 1.585 | Mod. | | *Volchonskoite* | Sil. | 001⊥X±? | Green. Gel. HCl | 416 |
| 1.585 | 1.585 | 1.560 | *Nontronite* | Sil. | 001⊥X± | Z ‖ fib. X=yellow, Z=green | 415 |
| 1.586 | 1.586 | 1.560 | *Uranospinite* | Phos. | 001⊥X | Ps. Tet. Yellow: X<Z | 147 |
| 1.587 | 1.610 | 1.582 | *Colemanite* | Bor. | 010⊥X | $Z\wedge c=83°$. 2V=55° | 93 |
| 1.587 | 1.613 | 1.52 | *Lanthanite* | Carb. | 001⊥X | $Y=a$. 2V=62° | 86 |
| 1.588 | 1.600 | 1.552 | Pyrophyllite | Sil. | 001⊥X | 2V=55°± | 263 |
| 1.588 | 1.588 | 1.578 | *Metavoltine* | Sul. | 0001⊥X? | Hex. Yellow: X<Z | 114 |
| 1.588 | 1.594 | 1.583 | **Celsian** | Sil. | 001; 010 | $Y=b$. $Z\wedge a=28°$. 2V=86° | 359 |
| 1.589 | Very weak | | *Rinneite* | Hal. | $10\bar{1}0$ | $Z=c$. G.=2.35. Sol. $H_2O$ | 33 |
| 1.589 | 1.594 | 1.583 | *Pharmacolite* | Phos. | 010⊥Z | $X\wedge c=+70°$. 2V=79° | 123 |
| 1.59 | Weak | | **Clinochlore** | Sil. | 001⊥Z | $Y=b$. 2E=Sm. Green: X>Z | 283 |
| 1.59 | .01± | | Corundophilite | Sil. | 001⊥Z | $Y=b$. 2E=50°±. Green: X>Z | 283 |
| 1.59 | 1.59 | 1.56 | Vermiculite | Sil. | 001⊥X | 2V=Sm. Brown: X<Z | 434 |
| 1.59 | 1.590 | 1.545 | **Talc** | Sil. | 001⊥X. $Z=b$ | 2V=20°±. Insol. | 262 |
| 1.59 | 1.59 | 1.555 | **Phlogopite** | Sil. | 001⊥X; $Y=b$ | 2V=10°±. Yellow: X<Z | 366 |
| 1.59 | .03± | | **Zinnwaldite** | Sil. | 001⊥X; $Z=b$ | 2V=35°±. Brown: X<Z | 270 |
| 1.59 | Very weak | | **Penninite** | Sil. | 001⊥X; $Y=b$ | 2V=0°±. Green: X<Z | 281 |
| 1.59± | Weak | | *Nouméite* | Sil. | Z ‖ fib. | 2E=Sm. Green | 261 |
| 1.59 | 1.598 | 1.586 | *Custerite* | Sil. | 001 | $X=b$. $Z\wedge c=6°$. 2E=105° | 412 |
| 1.59 | Very weak | | *Chlormankalite* | Hal. | $Z=c$ | Rhom. Yellow. Sol. $H_2O$ | 33 |
| 1.59 | 1.605 | 1.575 | *Catapleite* | Sil. | $X=c$; $Y=b$ | 2V=Lg. | 400 |
| 1.59 | 1.59 | 1.56 | *Connarite* | Sil. | 001⊥X | 2V=0°±. Green; pleo. | 280 |
| 1.59± | .01± | | *Jenkinsite* | Sil. | 001⊥X | 2V=Mod. Green | 281 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | − | $N_g$ | $N_p$ (or $N_g-N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.56 | 1.56 | 1.53 | *Nepouite* | Sil. | 001⊥X± | 2V=0°±. X=green, Z=yel. | 279 |
| | 1.565 | 1.570 | 1.550 | *Variscite* | Phos. | ? | G.=2.54. Sol. HCl | 140 |
| | 1.568 | 1.568 | 1.564 | Beryl | Sil. | X=*c* | Also biax. Pneumat. | 212 |
| | 1.57 | 1.570 | 1.545 | Mizzonite | Sil. | 100. X=*c* | Tet. Incl. common | 297 |
| 1.57 | | Very weak | | **Penninite** | Sil. | 001⊥Z | 2V=Sm. Green: X>Z | 281 |
| | 1.575 | 1.577 | 1.553 | *Autunite* | Phos. | 001⊥X. Y=*b* | 2V=33°. Yellow: X<Z | 146 |
| 1.58 | | .015± | | Amesite | Sil. | 001⊥Z | 2V=Sm. Ps. Hex. | 285 |
| 1.58 | | 1.615 | 1.540 | *Hambergite* | Bor. | 010⊥Y. X=*a* | G.=2.35. H.=7.5 | 91 |
| | 1.582 | 1.588 | 1.552 | **MUSCOVITE** | Sil. | 001⊥X | Z=*b*. 2V=47° | 267 |
| | 1.585 | 1.585 | 1.560 | *Nontronite* | Sil. | 001⊥X± | Z ‖ fib. X=yellow, Z=green | 415 |
| 1.587 | | 1.610 | 1.582 | *Colemanite* | Bor. | 010⊥X | Z∧*c*=83°. 2V=55° | 93 |
| 1.588 | | 1.594 | 1.583 | **Celsian** | Sil. | 001; 010 | Y=*b*. Z∧*a*=28°. 2V=86°± | 359 |
| | 1.59± | 1.590 | 1.587 | *Kaemmererite* | Sil. | 001⊥X | 2V=Sm. Purple: X<Z | 286 |
| 1.59 | | 1.597 | 1.584 | **Anthophyllite** | Sil. | 110 at 56° | Y=*b*. Z=*c*. 2V=85°± | 240 |
| 1.59 | | 1.597 | 1.584 | *Kupfferite* | Sil. | 110 at 56° | Y=*b*. Z∧*c*=11°. 2V=85°±. Green | 244 |
| 1.59 | | Weak | | Prochlorite | Sil. | 001⊥Z | Y=*b*. 2V=Sm. Green: X>Z | 284 |
| 1.59 | | .02 | | *Martinite* | Phos. | Y=*b*; Z=*a* | 2V=Lg. Sol. HCl | 124 |
| | 1.59 | 1.59 | 1.555 | **BIOTITE** | Sil. | 001⊥X; Y=*b* | 2V=0°±. Brown or green: X<Z | 272 |
| | 1.59 | 1.59 | 1.54 | Leverrierite | Sil. | 001⊥X± | Y=*b*; 2V=50°± | 433 |
| | 1.59 | .04± | | *Protolithionite* | Sil. | 001⊥X± | 2V=0°±. X=yel. Z=brown | 270 |
| | 1.59 | .04± | | Phengite | Sil. | 001⊥X± | 2V=Sm. | 267 |
| | 1.59 | Very weak | | Delessite | Sil. | 001⊥X | 2V=Sm. Green: X<Z | 282 |
| 1.591 | | 1.631 | 1.559 | *Hambergite* | Bor. | 010⊥Y; X=*a* | 2V=87°. G.=2.35 | 91 |
| | 1.591 | 1.59+ | 1.572 | *Hopeite* | Phos. | 100⊥Z; X=*b* | 2V=36° | 124 |
| | 1.591 | 1.591 | 1.573 | *Metavoltine* | Sul. | 0001⊥X? | 2V=0°. Yellow; X<Z | 114 |
| | 1.591 | 1.594 | 1.572 | *Priceite* | Bor. | 001, 110 | 2V=32° | 93 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.592 | 1.627 | 1.591 | *Catapleite* | Sil. | 110 at 60°± | Y=*b*; Z=*c*±. 2V=Sm. | 400 |
| 1.592 | 1.614 | 1.586 | *Colemanite* | Bor. | 010⊥X | Z∧*c*=83°. 2V=55° | 93 |
| 1.592 | 1.611 | 1.572 | *Johannite* | Sul. | 001, 011 | X=*b*±. Tr. 2V=Lg. | 118 |
| 1.592 | 1.592 | 1.582 | *Torbernite* | Phos. | 001⊥X | 2V=0°±. X=green, Z=yel. | 145 |
| 1.593 | 1.600 | 1.587 | **Celsian** | Sil. | 001, 010 | Y=*b*; Z∧*a*=28°. 2V=Lg. | 359 |
| 1.593± | 1.598 | 1.578 | Amblygonite | Phos. | 001, 100 | Tr. 2V=50°± | 152 |
| 1.593 | 1.593 | 1.563 | *Ganophyllite* | Sil. | 001⊥X± | Z=*b*. 2V=Sm. | 436 |
| 1.593 | 1.594 | 1.558 | *Kryptotile* | Sil. | 001⊥X | Y=*b*. 2V=Sm. | 421 |
| 1.594 | 1.598 | 1.594 | *Foshagite* | Sil. | Z ‖ fib. | 2V=Sm. Gel. HCl | 408 |
| 1.594 | 1.597 | 1.570 | *Astrolite* | Sil. | One⊥X | 2V=30° | 429 |
| 1.595 | 1.610 | 1.575 | *Variscite* | Phos. | ? | 2V=55°±. Sol. HCl | 140 |
| 1.595 | 1.602 | 1.590 | *Cuspidine* | Sil. | 001; Y=*b* | Z∧*c*=6°. 2E=110° | 412 |
| 1.595 | 1.62 | 1.57 | *Szmikite* | Sul. | One; Z=*b* | 2V=Lg. Sol. $H_2O$ | 104 |
| 1.595 | Strong | | *Fuchsite* | Sil. | 001⊥X | 2E=70°±. Green: X<Z | 269 |
| 1.595 | 1.595 | 1.585 | *Crandallite* | Phos. | X=*c* | Fibrous. Rare | 154 |
| 1.595 | 1.598 | 1.571 | *Leucophane* | Sil. | 001⊥X. 100⊥Y | 2V=39°. G.=2.96 | 210 |
| 1.596 | .024± | | *Autunite* | Phos. | 001⊥X. Y=*b* | 2V=33°. Yellow: X<Z | 146 |
| 1.597 | 1.616 | 1.577 | *Johannite* | Sul. | 001, 011 | X=*b*±. Tr. 2V=Lg. | 118 |
| 1.597 | 1.598 | 1.575 | Chrysocolla | Sil. | ? | 2V=Sm. Blue: X>Z | 411 |
| 1.598 | 1.605 | 1.586 | *Howlite* | Bor. | Z∧*c*=44°± | X=*b*. 2V=Lg. | 95 |
| 1.598 | 1.627 | 1.580 | Vivianite | Phos. | 010⊥X | Z∧*c*=28°. X=blue, Z=olive | 126 |
| 1.598 | 1.598 | 1.592 | *Dahllite* | Phos. | Z ‖ fib. | X=*c*. Sol. HCl | 161 |
| 1.60 | 1.60 | 1.56 | Mizzonite | Sil. | 100. X=*c* | Tet. Incl. common | 297 |
| 1.60 | 1.60 | 1.56 | Leverrierite | Sil. | 001⊥X± | Y=*b*. 2V=50°± | 433 |
| 1.6± | .025± | | Bowlingite | Sil. | 001⊥X± | 2E=Sm. X=yel. Z=green | 437 |
| 1.60 | 1.628 | 1.595 | *Cebollite* | Sil. | Ext. ‖ fib. | 2V=58°. Gel. HCl | 431 |
| 1.6± | .014 | | *Manandonite* | Bor. | 001⊥Z | 2E=25°–30° | 95 |
| 1.600 | 1.602 | 1.586 | *Spencerite* | Phos. | 100⊥X±. 010 | Z=*b*. 2V=49°. Lam. twin. | 137 |
| 1.60± | 1.603 | 1.595 | *Riversidite* | Sil. | Z ‖ fib. | G.=2.61 | 409 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | − | $N_g$ or $N_g-N_p$ | $N_p$ | Mineral | Chem. | Cleavage Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.56 | 1.56 | 1.53 | *Nepouite* | Sil. | 001⊥X± | 2V=0°±. X=green, Z=yel. | 279 |
| | 1.568 | 1.568 | 1.564 | Beryl | Sil. | X=$c$ | Also biax. Pneumat. | 212 |
| 1.57 | | Very weak | | **Penninite** | Sil. | 001⊥Z | 2V=Sm. Green: X>Z | 281 |
| 1.58 | | .015± | | Amesite | Sil. | 001⊥Z | 2V=Sm. Ps. Hex. | 285 |
| | 1.582 | 1.588 | 1.552 | **MUSCOVITE** | Sil. | 001⊥X | Z=$b$. 2V=47° | 267 |
| | 1.585 | 1.585 | 1.560 | *Nontronite* | Sil. | 001⊥X± | Z ∥ fib. X=yellow, Z=green | 415 |
| 1.59 | | 1.597 | 1.584 | **Anthophyllite** | Sil. | 110 at 56° | Y=$b$. Z=$c$. 2V=85°± | 240 |
| 1.59 | | 1.597 | 1.584 | *Kupfferite* | Sil. | 110 at 56°.Y=$b$ | Z∧$c$=11°. 2V=85°±. Green | 244 |
| 1.59 | | Weak | | Prochlorite | Sil. | 001⊥Z | Y=$b$. 2V=Sm. Green: X>Z | 284 |
| 1.59 | | .02 | | *Martinite* | Phos. | Y=$b$; Z=$a$± | 2V=Lg. Sol. HCl | 124 |
| | 1.59 | 1.59 | 1.555 | **BIOTITE** | Sil. | 001⊥X. Y=$b$ | 2V=0°±. Br. or gr.: X<Z | 272 |
| | 1.59 | .04± | | *Protolithionite* | Sil. | 001⊥X± | 2V=0°±. X=yel., Z=br. | 270 |
| | 1.59 | .04± | | Phengite | Sil. | 001⊥X± | 2V=Sm. | 267 |
| | 1.59 | Very weak | | Delessite | Sil. | 001⊥X± | 2V=Sm. Green: X<Z | 282 |
| | 1.593 | 1.593 | 1.563 | *Ganophyllite* | Sil. | 001⊥X | Z=$b$. 2V=Sm. | 436 |
| 1.598 | | 1.627 | 1.580 | Vivianite | Phos. | 010⊥X | Z∧$c$=28°. X=blue, Z=olive | 126 |
| | 1.598 | 1.598 | 1.592 | *Dahllite* | Phos. | Z ∥ fib. | X=$c$. Sol. HCl | 161 |
| | 1.60 | 1.60 | 1.56 | Meionite | Sil. | 100. X=$c$ | Tet. Dec. HCl | 297 |
| | 1.602 | 1.602 | 1.595 | Beryl | Sil. | X=$c$ | G.=2.9. Insol. | 212 |
| 1.602 | | 1.638 | 1.590 | *Haidingerite* | Phos. | 010⊥X | 2V=58°. G.=2.85 | 123 |
| 1.603 | | 1.615 | 1.594 | *Fremontite* | Phos. | 001⊥X± | Tr.? 2V=Lg. | 152 |
| | 1.603 | 1.607 | 1.593 | *Crestmorite* | Sil. | 100? Z∧$c$=12° | 2V=Lg. | 409 |
| | 1.603 | 1.611 | 1.584 | *Bertrandite* | Sil. | 001⊥Z. X=$a$ | 2V=74° | 410 |
| | 1.604 | 1.636 | 1.582 | Vivianite | Phos. | 010⊥X | Z∧$c$=28°. X=blue, Z=olive | 126 |
| | 1.605 | 1.611 | 1.51 | *Amarantite* | Sul. | 100⊥X±; 010 | Y=$b$. 2E=60°. Yel.:X<Z | 109 |
| 1.606 | | .02 | | *Martinite* | Phos. | Y=$b$. Z=$a$± | Mon.? 2V=Lg. | 124 |
| 1.606± | | 1.608 | 1.606 | *Eudialite* | Sil. | 0001⊥Z | Yellow, etc. X<Z | 417 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.606± | 1.633 | 1.595 | Pectolite | Sil. | 100⊥X±; 001 | Y=*c*. 2V=60° | 419 |
| 1.606 | 1.622 | 1.593 | Chondrodite[1] | Sil. | X∧*a*=26°± | Z=*b*. 2V=80°± | 196 |
| 1.607 | Weak | | *Eucolite* | Sil. | 0001⊥X | Yellow, etc. X>Z | 417 |
| 1.608 | .03 | | *Ganophyllite* | Sil. | 001⊥X±; 010 | Z=*b*. 2V=Sm. Yel.: X>Z | 436 |
| 1.609 | .025± | | Glauconite | Sil. | 001⊥X± | 2V=Sm. Green: X<Z | 436 |
| 1.61 | Very weak | | **Penninite** | Sil. | 001⊥Z± | 2V=Sm. Green: X>Z | 281 |
| 1.61 | .015± | | Amesite | Sil. | 001⊥Z± | 2V=Sm. G.=2.8 | 285 |
| 1.61 | 1.613 | 1.610 | *Eudialite* | Sil. | 0001⊥Z | Yellow, etc. X<Z | 417 |
| 1.61 | .04± | | **MUSCOVITE** | Sil. | 001⊥X± | 2V=45°± | 267 |
| 1.61 | .04± | | Phengite | Sil. | 001⊥X± | 2V=Sm. | 267 |
| 1.61 | Very weak | | Delessite | Sil. | 001⊥X± | 2V=Sm. Green: X<Z | 282 |
| 1.61± | 1.612 | 1.605 | *Hillebrandite* | Sil. | 110 | Z=*c*. 2E=70°±. Sol. HCl. | 408 |
| 1.61 | Very weak | | Ripidolite | Sil. | 001⊥Z± | 2V=Sm. Green: X>Z | 284 |
| 1.61 | 1.617 | 1.607 | Topaz | Sil. | 001⊥Z | 2V=65±°. G.=3.5 | 198 |
| 1.61 | Very weak | | *Metatorbernite* | Phos. | 001⊥Z± | 2V=Sm. X=blue, Z=green | 145 |
| 1.61 | Weak | | Diabantite | Sil. | 001⊥X± | 2V=Sm. Green: X<Z | 283 |
| 1.611 | 1.651 | 1.610 | *Pseudowollast.* | Sil. | 001⊥Z± | 2V=Sm. G.=2.905 | 402 |
| 1.612 | 1.621 | 1.592 | *Herderite* | Phos. | Z∧*c*=−3° | Y=*b*. 2V=74° | 134 |
| 1.612 | 1.612 | 1.607 | *Fluocerite* | Hal. | 0001⊥X | G.=6. Yellow | 33 |
| 1.613 | 1.619 | 1.609 | *Stokesite* | Sil. | 110 at 38° | X=*a*. Y=*b*. 2V=70° | 409 |
| 1.613 | 1.649 | 1.602 | *Anapaite* | Phos. | 101, 010 | Tr. 2V=53° | 128 |
| 1.613 | 1.613 | 1.593 | *Meliphanite* | Sil. | 001⊥X | Tet. Yellow: X<Z | 210 |
| 1.613 | 1.624 | 1.600 | **Tremolite** | Sil. | 110 at 56° | Y=*b*. Z∧*c*=17°. 2V=85° | 245 |
| 1.614 | 1.630 | 1.607 | *Montebrazite* | Phos. | 001, 100 | 2V=80°±. G.=3± | 152 |
| 1.614 | Weak | | *Francolite* | Phos. | X=*c* | Also biax. G.=3.1 | 161 |
| 1.614 | 1.616 | 1.594 | *Phosphophyllite* | Phos. | 100, 010 | Y∧*a*=50°. Z=*b*. 2V=50°± | 125 |
| 1.615 | 1.615 | 1.575 | Meionite | Sil. | 100. X=*c* | G.=2.8 | 297 |
| 1.617 | 1.636 | 1.614 | Hemimorphite | Sil. | 110 at 76° | X=*b*. Z=*c*. 2V=46° | 211 |
| 1.617 | 1.655 | 1.588 | *Kyanotrichite* | Sul. | X=*a*; Z=*c* | 2V=83°. Blue: X<Z | 116 |
| 1.618 | .02 | | *Fremontite* | Phos. | 001⊥X± | Tr.? 2V=Lg. | 152 |
| 1.618 | 1.618 | 1.611 | *Fluocerite* | Hal. | 0001⊥X | G.=6. Yellow | 33 |

[1] E. S. Larsen: *Am. Mineral.*, XIII, 1928, p. 354.

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g - N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.56 | 1.56 | 1.53 | *Nepouite* | Sil. | 001 ⊥ X± | 2V = 0°±. X = gr., Z = yel. | 279 |
| | 1.585 | 1.585 | 1.560 | *Nontronite* | Sil. | 001 ⊥ X± | Z ǁ fib. X = yel., Z = green | 415 |
| 1.59 | | 1.597 | 1.584 | **Anthophyllite** | Sil. | 110 at 56° | Y = *b*. Z = *c*. 2V = 85°± | 240 |
| 1.59 | | 1.597 | 1.584 | *Kupfferite* | Sil. | 110 at 56°. Y = *b* | Z∧*c* = 11°. 2V = 85°±. Gr. | 244 |
| 1.59 | | Weak | | Prochlorite | Sil. | 001 ⊥ Z. Y = *b* | 2V = Sm. Green: X>Z | 284 |
| | 1.59 | 1.59 | 1.555 | **BIOTITE** | Sil. | 001 ⊥ X. Y = *b* | 2V = 0°±. Br. or gr.: X<Z | 272 |
| | 1.59 | .04± | | *Protolithionite* | Sil. | 001 ⊥ X± | 2V = 0°±. X = yel., Z = br. | 270 |
| | 1.598 | 1.598 | 1.592 | *Dahllite* | Phos. | Z ǁ fib. | X = *c*. Sol. HCl | 161 |
| 1.606 | | 1.622 | 1.593 | Chondrodite | Sil. | X∧*a* = 26°± | Z = *b*. 2V = 80°± | 196 |
| | 1.607 | Weak | | *Eucolite* | Sil. | 0001 ⊥ X | Yellow, etc.: X>Z | 417 |
| | 1.609 | .025± | | Glauconite | Sil. | 001 ⊥ X± | 2V = Sm. Green: X<Z | 436 |
| 1.61 | | Very weak | | Ripidolite | Sil. | 001 ⊥ Z± | 2V = Sm. Green: X>Z | 284 |
| 1.61 | | 1.617 | 1.607 | Topaz | Sil. | 001 ⊥ Z | 2V = 65°. G. = 3.5 | 198 |
| 1.61 | | Very weak | | *Metatorbernite* | Phos. | 001 ⊥ Z± | 2V = Sm. X = blue, Z = green | 145 |
| | 1.61 | Very weak | | Diabantite | Sil. | 001 ⊥ X± | 2V = Sm. Green: X<Z | 283 |
| | 1.613 | 1.624 | 1 600 | **Tremolite** | Sil. | 110 at 56°. Y = *b* | Z∧*c* = 17°. 2V = 85°± | 245 |
| | 1.614 | Weak | | *Francolite* | Phos. | X = *c* | Also biax. G. = 3.1 | 161 |
| 1.618 | | 1.633 | 1.613 | **Pargasite** | Sil. | 110 at 56° | Y = *b*. Z∧*c* = 25°±. 2V = 60°± Yellow, green: X<Z | 248 |
| | 1.618 | 1.618 | 1.552 | *Chalcophyllite* | Phos. | 0001 ⊥ X | G. = 2.5. Green | 136 |
| 1.62 | | Weak | | Prochlorite | Sil. | 001 ⊥ Z± | 2V = Sm. Green: X>Z | 284 |
| 1.62 | | 1.63 | 1.61 | *Kupfferite* | Sil. | 110 at 56° | Z∧*c* = 12°±. 2V = 80°±. Yel., green: X<Z | 244 |
| 1.62 | | 1.65 | 1.61 | *Turquois* | Phos. | 1$\bar{1}$0. Tric. | 2V = 40°. Blue; pleo. | 157 |
| 1.62 | | 1.654 | 1.620 | *Churchite* | Phos. | One ⊥ Z | 2V = 0°±. Sol. HCl | 156 |
| | 1.62 | 1.649 | 1.575 | *Camsellite* | Bor. | X ǁ elong. | 2V = Lg. | 91 |
| 1.620 | | 1.637 | 1.617 | *Afwillite* | Sil. | 001; Y = *b* | X∧*c* = 30°. 2V = 55° | 412 |
| | 1.62 | .02± | | *Kreuzbergite* | Phos. | 010? | Y = *c*? 2V = 90°± | 141 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.620 | 1.630 | 1.620 | *Goyazite* | Phos. | 0001 ⊥ Z | Brown: X>Z | 153 |
| 1.62 | 1.63 | 1.61 | Cummingtonite | Sil. | 110 at 55° | Y = b. Z∧c = 15°±. 2V = 90°± Yellow: X<Z | 243 |
| 1.620 | .015± | | **Wollastonite** | Sil. | 100, 001 | X∧c = 32°. Y = b. 2V = 40°± | 401 |
| 1.621 | 1.621 | 1.619 | *Gillespite* | Sil. | 0001 ⊥ X | Hex.? Red: X>Z | 401 |
| 1.622 | 1.658 | 1.618 | *Arakawaite* | Phos. | Z∧c = −36° | 2V = 38°. Green | 138 |
| 1.623 | 1.631 | 1.622 | Celestite | Sul. | 001, 110, 010 | X = c. 2V = 51°. G. = 4.0 | 99 |
| 1.623 | 1.631 | 1.621 | *Uranopilite* | Sul. | X ⊥ lath.± | 2V = Sm. Yellow | 117 |
| 1.623 | 1.623 | 1.610 | *Uranocircite* | Phos. | 001 ⊥ X | 2V = 10°. Yellow: X<Z | 147 |
| 1.623 | 1.623 | 1.620 | *Merrillite* | Phos. | 10$\bar{1}$0. X = c | Also biax. +? | 149 |
| 1.623 | 1.623 | 1.602 | *Bazzite* | Sil. | X = c | Hex. X = blue, Z = yellow | 414 |
| 1.624 | 1.645 | 1.615 | Prehnite | Sil. | 001 ⊥ Z | X = a. 2V = 66°±. Sol. HCl | 430 |
| 1.624 | 1.652 | 1.617 | Humite | Sil. | X = a; Z = b | 2V = 68°. Yellow: X>Z | 197 |
| 1.625 | 1.71 | 1.615 | *Bisbeeite* | Sil. | Z ‖ elong. | 2V = Sm. Colorless or X = brown, Z = green | 411 |
| 1.625 | Weak | | *Gorceixite* | Phos. | Rhom.? | G. = 3.1 | 153 |
| 1.625 | 1.665 | 1.615 | *Destinezite* | Sul. | Z∧elong. = 16° | 2V = Sm. | 121 |
| 1.625 | 1.637 | 1.614 | *Parahopeite* | Phos. | 010; X = a± | Tr. 2V = 90°± | 128 |
| 1.625 | .025± | | **Tremolite** | Sil. | 110 at 56° | Y = b. Z∧c = 15°. 2V = 85°± | 245 |
| 1.625 | Strong | | *Roscherite* | Phos. | 001; 010 ⊥ X | 2V = Lg. X = green, Z = br. | 156 |
| 1.625 | .025± | | **Actinolite** | Sil. | 110 at 56° | Y = b. Z∧c = 15°. 2V = 85°±. X = yellow, Z = green | 245 |
| 1.626 | 1.626 | 1.608 | *Bazzite* | Sil. | X = c | Hex. X = blue, Z = yellow | 414 |
| 1.627 | Weak | | *Francolite* | Phos. | X = c | Also biax. Sol. HCl | 161 |
| 1.627 | 1.627 | 1.582 | *Troegerite* | Phos. | 001 ⊥ X | Also biax. Yellow | 147 |
| 1.628 | Weak | | *Metatorbernite* | Phos. | 001 ⊥ Z | Abn. int. colors | 145 |
| 1.629 | 1.639 | 1.629 | *Goyazite* | Phos. | 0001 ⊥ Z | Colorless or brown: X>Z | 153 |
| 1.629 | 1.630 | 1.620 | *Margarite* | Sil. | 001 ⊥ X± | 2V = Sm. −67°. G. = 3 | 288 |
| 1.63 | Very weak | | Ripidolite | Sil. | 001 ⊥ Z± | 2V = Sm. Green: X>Z | 284 |
| 1.63 | Very weak | | Diabantite | Sil. | 001 ⊥ X± | 2V = Sm. Green: X<Z | 283 |
| 1.63 | .037 | | *Nepouite* | Sil. | 001 ⊥ X± | 2V = Sm. Green: X<Z | 279 |
| 1.63± | 1.635 | 1.629 | *Fibrolite* | Sil. | 010 ⊥ X | 2V = 30°±. Fibrous | 200 |

## TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g - N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.585 | 1.585 | 1.560 | *Nontronite* | Sil. | 001 ⊥ X ± | Z ∥ fib. X = yel., Z = green | 415 |
| 1.59 | | 1.597 | 1.584 | **Anthophyllite** | Sil. | 110 at 56° | Y = *b*. Z = *c*. 2V = 85° ± | 240 |
| | 1.59 | 1.59 | 1.555 | **BIOTITE** | Sil. | 001 ⊥ X. Y = *b* | 2V = 0° ±. Br. or gr.: X < Z | 272 |
| | 1.59 | .04 ± | | *Protolithionite* | Sil. | 001 ⊥ X ± | 2V = 0° ±. X = yel., Z = br. | 270 |
| | 1.598 | 1.598 | 1.592 | *Dahllite* | Phos. | Z ∥ fib. | X = *c*. Sol. HCl | 161 |
| 1.606 | | 1.622 | 1.593 | Chondrodite | Sil. | X ∧ *a* = 26° ± | Z = *b*. 2V = 80° ± | 196 |
| | 1.607 | Weak | | *Eucolite* | Sil. | 0001 ⊥ X | Yellow, etc. X > Z | 417 |
| | 1.609 | .025 ± | | Glauconite | Sil. | 001 ⊥ X ± | 2V = Sm. Green: X < Z | 436 |
| 1.61 | | 1.617 | 1.607 | Topaz | Sil. | 001 ⊥ Z | 2V = 65. G. = 3.5 | 198 |
| 1.618 | | 1.633 | 1.613 | **Pargasite** | Sil. | 110 at 56° | Z ∧ *c* = 25° ±. 2V = 60° ±. Yellow, green: X < Z | 248 |
| | 1.618 | 1.618 | 1.552 | *Chalcophyllite* | Phos. | 0001 ⊥ X | G. = 2.5. Green | 136 |
| 1.62 | | 1.63 | 1.61 | Cummingtonite | Sil. | 110 at 55° | Y = *b*. Z ∧ *c* = 15° ±. 2V = 90° ±. Yellow: X < Z | 243 |
| | 1.620 | .015 ± | | **Wollastonite** | Sil. | 100, 001 | X ∧ *c* = 32°. Y = *b*. 2V = 40° | 401 |
| 1.624 | | 1.645 | 1.615 | Prehnite | Sil. | 001 ⊥ Z | X = *a*. 2V = 66° ±. Sol. HCl | 430 |
| 1.624 | | 1.652 | 1.617 | Humite | Sil. | X = *a*. Z = *b* | 2V = 68°. Yellow: X > Z | 197 |
| | 1.625 | .025 ± | | **Actinolite** | Sil. | 110 at 56° | Z ∧ *c* = 15°. 2V = 80° ±. X = yellow, Z = green | 245 |
| | 1.629 | 1.630 | 1.620 | *Margarite* | Sil. | 001 ⊥ X ± | 2V = Sm. −67°. G. = 3 | 288 |
| | 1.630 | 1.630 | 1.585 | *Troegerite* | Phos. | 010 ⊥ X | 2V = Sm. Yellow | 147 |
| | 1.63 | 1.638 | 1.625 | Celadonite | Sil. | 001 ⊥ X ± | 2V = Sm. Green: X < Z | 436 |
| | 1.63 | .02 ± | | *Bityite* | Sil. | 001 ⊥ X | Ps. Hex. 2V = Sm. | 427 |
| | 1.63 | 1.64 | 1.62 | *Carpholite* | Sil. | 010 ⊥ X | Z = *c*. 2V = 60° ±. Yellow: X > Z | 431 |
| | 1.63 | .09 ± | | *Stilpnomelane* | Sil. | 001 ⊥ X ± | 2V = Sm. Gr. or br.: X < Z | 435 |
| | 1.63 | .02 ± | | **Tourmaline (Mg)** | Sil. | X = *c* | Colorless or brown: X < Z. Insol. | 301 |
| | 1.63 | Very weak | | Aphrosiderite | Sil. | 001 ⊥ X ± | 2V = Sm. Green: X < Z | 284 |
| 1.631 | | 1.638 | 1.629 | Topaz | Sil. | 001 ⊥ Z | 2V = 48°. G. = 3.55 | 198 |
| | 1.632 | 1.632 | 1.575 | *Chalcophyllite* | Phos. | 0001 ⊥ X | G. = 2.5. Green | 136 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1.632** | 1.640 | 1.631 | *Picropharmacolite* | Phos. | 010⊥Y; 100 | X∧c=37°. 2V=40° | 125 |
| 1.632 | 1.639 | 1.603 | Lazulite | Phos. | X∧c=−9° | Y=b. 2V=69°. Blue: X<Z | 154 |
| 1.632 | 1.632 | 1.630 | **Apatite (F)** | Phos. | X=c | White or tinted: X>Z | 129 |
| 1.632 | 1.632 | 1.602 | *Bementite* | Sil. | 001⊥X | Y=b. 2V=0°±. Yellow: X<Z | 409 |
| 1.633 | 1.635 | 1.621 | **Wollastonite** | Sil. | 100, 001 | X∧c=32°. Y=b. 2V=40°± | 401 |
| 1.633 | 1.639 | 1.629 | **Andalusite** | Sil. | 110 at 89° | X=c. 2V=84°. Red±: X>Z | 201 |
| **1.633** | 1.639 | 1.633 | **Akermanite** | Sil. | 110 at 90° | Z=c. Tet. Gel. HCl | 209 |
| 1.633 | 1.636 | 1.630 | *Danburite* | Sil. | X=b. Y=c | 2V=88°± | 210 |
| 1.634 | 1.634 | 1.627 | *Dahllite* | Phos. | Z ‖ fib. | X=c. Sol. HCl | 161 |
| 1.635 | .04 | | *Protolithionite* | Sil. | 001⊥X± | 2V=0°±. Brown: X<Z | 270 |
| 1.635 | 1.657 | 1.613 | *Sklodowskite* | Sil. | 001⊥Y | 2V=Lg. Yellow: X<Z | 441 |
| 1.635 | 1.635 | 1.615 | Tourmaline (Li) | Sil. | X=c | Colorless or X<Z. Insol. | 301 |
| 1.636± | 1.644 | 1.623 | *Gedrite* | Sil. | 110 at 56° | X=a; Z=c. 2V=79°. Insol. | 240 |
| **1.636** | 1.660 | 1.631 | *Schizolite* | Sil. | 100⊥Y±; 001 | Tr. 2E=83° | 420 |
| 1.636 | 1.639 | 1.602 | *Grandidierite* | Sil. | 100⊥X; 010⊥Z | 2V=30°. Blue: Y<Z | 421 |
| 1.636 | 1.644 | 1.609 | *Inesite* | Sil. | 010⊥X±; 100 | 2V=60°. Pink; pleo. | 413 |
| 1.637 | .006 | | *Danburite* | Sil. | X=b; Y=c | 2V=88°± | 210 |
| **1.637** | 1.648 | 1.636 | Barite | Sul. | 001, 110 | X=c. 2V=38°. Insol. | 100 |
| 1.637 | 1.637 | 1.581 | *Ekmannite* | Sil. | X⊥001± | Brown: X<Z | 281 |
| 1.638± | 1.639 | 1.621 | Glaucophane | Sil. | 110 at 56° | Z∧c=5°±. 2V=45°±. Blue: X<Z | 258 |
| 1.64 | 1.65 | 1.625 | **Actinolite** | Sil. | 110 at 56° | Z∧c=15°±. 2V=80°±. X=yellow, Z=green | 245 |
| **1.640** | 1.645 | 1.640 | **Akermanite** | Sil. | 110 at 90° | Z=c. Tet. Gel. HCl | 209 |
| **1.64** | .01 | | *Svanbergite* | Sul. | 0001⊥Z | Rhom. Also biax. | 119 |
| **1.64** | 1.66 | 1.64 | *Roeblingite* | Sil. | X ‖ fib. | 2V=Sm. G.=3.43 | 440 |
| **1.64** | .02 | | *Barrandite* | Phos. | Z ‖ fib. | 2V=Lg. G.=2.6± | 140 |
| **1.640** | 1.697 | 1.640 | *Planchéite* | Sil. | Z ‖ fib. | 2V=0°? Blue: X<Z | 411 |
| 1.64± | .01 | | *Chamosite* | Sil. | 001⊥X | 2V=Sm. Green: X<Z | 286 |
| 1.64 | Mod.? | | *Eremeyevite* | Bor. | Ps. Hex. | 2V=Sm. G.=3.28 | 94 |
| 1.64 | .02± | | **HORNBLENDE** | Sil. | 110 at 56° | Y=b. Z∧c=20°±. 2V=80°±. X=yellow, Z=green | 247 |
| 1.64 | .03± | | **Tourmaline (Fe)** | Sil. | X=c | Brown, green, blue: X<Z | 301 |
| 1.64 | Weak | | **Melilite** | Sil. | X or Z=c | Abn. int. colors | 208 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g-N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.585 | 1.585 | 1.560 | *Nontronite* | Sil. | 001 ⊥ X± | Z ‖ fib. X=yel., Z=green | 415 |
| 1.59 | | 1.597 | 1.584 | **Anthophyllite** | Sil. | 110 at 56° | Y=*b*. Z=*c*. 2V=85°± | 240 |
| | 1.59 | 1.59 | 1.555 | **BIOTITE** | Sil. | 001 ⊥ X. Y=*b* | 2V=0°±. Br. or gr.: X<Z | 272 |
| 1.606 | | 1.622 | 1.593 | Chondrodite | Sil. | X ∧ *a*=26°± | Z=*b*. 2V=80°± | 196 |
| | 1.607 | Weak | | *Eucolite* | Sil. | 0001 ⊥ X | Yellow, etc.: X>Z | 417 |
| | 1.609 | .025± | | Glauconite | Sil. | 001 ⊥ X± | 2V=Sm. Green: X<Z | 436 |
| 1.618 | | 1.633 | 1.613 | **Pargasite** | Sil. | 110 at 56° | Z∧*c*=25°±. 2V=60°±. Yellow, green: X<Z | 248 |
| 1.62 | | 1.63 | 1.61 | Cummingtonite | Sil. | 110 at 55° | Z∧*c*=15°±. 2V=90°±. Yellow: X<Z | 243 |
| 1.624 | | 1.645 | 1.615 | Prehnite | Sil. | 001 ⊥ Z | X=*a*. 2V=66°±. Sol. HCl | 430 |
| 1.624 | | 1.652 | 1.617 | Humite | Sil. | X=*a*. Z=*b* | 2V=68°. Yellow: X>Z | 197 |
| | 1.629 | 1.630 | 1.620 | *Margarite* | Sil. | 001 ⊥ X± | 2V=Sm.—67°. G.=3 | 288 |
| | 1.63 | .09± | | *Stilpnomelane* | Sil. | 001 ⊥ X± | 2V=Sm. Gr. or br.: X<Z | 435 |
| | 1.63 | .02± | | **Tourmaline (Mg)** | Sil. | X=*c* | Colorless or brown: X<Z. Insol. | 301 |
| | 1.63 | Very weak | | Aphrosiderite | Sil. | 001 ⊥ X± | 2V=Sm. Green: X<Z | 284 |
| | 1.632 | 1.632 | 1.630 | **Apatite (F)** | Phos. | X=*c* | Colorless or tinted: X<Z | 128 |
| | 1.632 | 1.632 | 1.602 | *Bementite* | Sil. | 001 ⊥ X | Y=*b*. 2V=0°±. Yellow: X<Z. | 409 |
| | 1.633 | 1.639 | 1.629 | **Andalusite** | Sil. | 110 at 89° | X=*c*. 2V=84°. Red±: X>Z | 201 |
| | 1.635 | 1.635 | 1.615 | Tourmaline (Li) | Sil. | X=*c* | Colorless or tinted: X<Z | 301 |
| | 1.64 | .02± | | **HORNBLENDE** | Sil. | 110 at 56° | Y=*b*. Z∧*c*=20°±. 2V=80°±. X=yellow, Z=green | 247 |
| | 1.64 | .03± | | **Tourmaline (Fe)** | Sil. | X=*c* | Brown, green, blue: X<Z | 301 |
| 1.64 | | Weak | | **Melilite** | Sil. | X or Z=*c* | Abnor. int. colors | 208 |
| 1.64 | | .02 | | *Barrandite* | Phos. | Z ‖ fib. | 2V=Lg. G.=2.6± | 140 |
| 1.641 | | 1.652 | 1.633 | *Fairfieldite* | Phos. | 010, 100 | Tr Sol. HCl | 127 |
| | 1.642 | 1.647 | 1.584 | *Serpierite* | Sul. | 001 ⊥ X | 2V=35°. Green: X<Z | 102 |
| 1.642 | | 1.665 | 1.632 | Prehnite | Sil. | 001 ⊥ Z | X=*a*. 2V=65°±. G.=2.9 | 430 |
| | 1.643 | 1.645 | 1.632 | *Margarite* | Sil. | 001 ⊥ X | 2V=Sm. G.=3.0–3.1 | 288 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.643 | 1.643 | 1.634 | *Eucolite* | Sil. | 0001 ⊥ X | Colorless or X>Z | 417 |
| 1.643 | .035± | | Humite | Sil. | X = *a*; Z = *b* | 2V = 68° ±. Yel. ±: X>Z | 197 |
| 1.643 | 1.643 | 1.623 | *Zeunerite* | Phos. | 001 ⊥ X | 2V = 0° ±. Green: X<Z | 146 |
| 1.644 | 1.647 | 1.640 | **Andalusite** | Sil. | 110 at 89° | X = *c*; Z = *a*. 2V = 85°. Colorless or X>Z | 201 |
| 1.644 | 1.654 | 1.636 | *Fairfieldite* | Phos. | 010, 100 | Tr. G. = 3.1. Sol. HCl | 127 |
| 1.644? | 1.697 | 1.644 | *Dioptase* | Sil. | 10$\bar{1}$1. Z = c | Also biax. Green: X>Z | 186 |
| 1.644 | 1.654 | 1.642 | Mullite | Sil. | 010 ⊥ Y; Z = *c* | 2V = 50° ±. Pink ±: X<Z | 235 |
| 1.645 | 1.663 | 1.635 | Chondrodite | Sil. | X ∧ *a* = 26°; Z = *b* | 2V = 80° ±. Yellow: X<Z | 196 |
| 1.645 | 1.645 | 1.612 | Glauconite | Sil. | 001 ⊥ X ± | 2V = Sm. Green: X<Z | 436 |
| 1.646 | 1.649 | 1.630 | *Gastaldite* | Sil. | 110 at 56° | Z ∧ *c* = 6° ±. 2V = 43° ±. G. = 3.0–3.1 | 259 |
| 1.648 | 1.648 | 1.643 | **Apatite (F)** | Phos. | X = *c* | Colorless or X>Z | 128 |
| 1.648 | 1.674 | 1.643 | *Reddingite* | Phos. | 010 ⊥ Y; Z = *c* | 2V = 41°. Brown: X<Y | 124 |
| 1.649 | 1.658 | 1.646 | *Mosandrite* | Sil. | 100 ⊥ Z ± | 2V = 74°. Brown | 423 |
| 1.649 | 1.660 | 1.585 | *Herrengrundite* | Sul. | 001, 110 | X = *c* ±. Z = *b*. 2V = 39 | 104 |
| 1.65 | Very weak | | Aphrosiderite | Sil. | 001 ⊥ X ± | 2V = Sm. Green: X<Z | 284 |
| 1.65 | 1.65 | 1.63 | Tourmaline (Li) | Sil. | X = *c* | Colorless or X>Z | 301 |
| 1.65± | .03± | | *Barrandite* | Phos. | Z ∥ fib. | 2V = Sm. G. = 3.43 | 140 |
| 1.65± | .01± | | *Hellandite* | Sil. | Z ∧ *c* = −44° | X = *b*. 2V = 80° ±. Brown | 425 |
| 1.65 | 1.655 | 1.625 | *Nontronite* | Sil. | 001 ⊥ X ± | Z ∥ fib. X = yel., Z = green | 415 |
| 1.65 | 1.65 | 1.624 | *Bementite* | Sil. | 001 ⊥ Z | Y = *b*. 2V = 0° ±. Yellow: X<Z | 409 |
| 1.65 | 1.655 | 1.608 | Iddingsite | Sil. | 100 ⊥ X; 001 ⊥ Z | 2V = 40° ±. Brown: X<Z | 437 |
| 1.65 | 1.65 | 1.575 | *Szaibelyite* | Bor. | Acicular | G. = 2.76–3.0 | 92 |
| 1.650 | 1.682 | 1.610 | *Epistolite* | Sil. | 001 ⊥ Z ± | Y = *b*. 2V = 80°. G. = 2.89 | 442 |
| 1.65 | 1.656 | 1.645 | *Koninckite* | Phos. | X ∥ fib. | Yellow. Sol. HCl | 142 |
| 1.65 | .01 | | *Auerlite* | Ox. | Z = *c* | Tet. Yellow | 185 |
| 1.65 | 1.65 | 1.62 | *Friedelite* | Sil. | 0001 ⊥ X | 2V = 0° ±. Pink ± | 408 |
| 1.65 | 1.66 | 1.64 | **Allanite** | Sil. | Y = *b* | 2V = Lg. Green: X<Z | 316 |
| 1.65 | Very weak | | **Apatite (Cl)** | Phos. | X = *c* | Colorless or X>Z | 128 |
| 1.65 | Very weak | | Daphnite | Sil. | 001 ⊥ X ± | 2V = 0° ±. Green: X<Z | 285 |
| 1.65 | .01± | | Thuringite | Sil. | 001 ⊥ X ± | 2V = 0° ±. Green: X<Z | 285 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | − | $N_g$ | $N_p$ or $N_g - N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.59 | | 1.597 | 1.584 | **Anthophyllite** | Sil. | 110 at 56° | $Y=b$. $Z=c$. $2V=85°\pm$ | 240 |
| | 1.59 | 1.59 | 1.555 | **BIOTITE** | Sil. | 001 ⊥ X. $Y=b$ | $2V=0°\pm$. Brown or green: X<Z | 272 |
| 1.618 | | 1.633 | 1.613 | **Pargasite** | Sil. | 110 at 56° | $Z\wedge c=25°$. $2V=60°\pm$. Yellow, green: X<Z | 248 |
| 1.62 | | 1.63 | 1.61 | Cummingtonite | Sil. | 110 at 55° | $Z\wedge c=15°\pm$. $2V=90°\pm$. Yellow: X<Z | 243 |
| | 1.63 | | .09± | *Stilpnomelane* | Sil. | 001 ⊥ X± | 2V = Sm. Green or brown: X<Z | 435 |
| | 1.63 | | .02± | **Tourmaline (Mg)** | Sil. | $X=c$ | Colorless or brown: X<Z Insol. | 301 |
| | 1.64 | | .02± | **HORNBLENDE** | Sil. | 110 at 56° | $Y=b$. $Z\wedge c=20°\pm$. $2V=80°\pm$. X = yellow, Z = green | 247 |
| | .64 | | .03± | **Tourmaline (Fe)** | Sil. | X=c | Brown, green, blue: X<Z | 301 |
| 1.64 | | | Weak | **Melilite** | Sil. | X or $Z=c$ | Abnor. int. colors | 208 |
| 1.644 | | 1.654 | 1.642 | Mullite | Sil. | 010 ⊥ Y. $Z=c$ | $2V=50°\pm$. Pink±: X<Z | 201 |
| | 1.646 | 1.649 | 1.630 | *Gastaldite* | Sil. | 110 at 56° | $Z\wedge c=6°\pm$. $2V=43°\pm$ | 259 |
| 1.648 | | 1.674 | 1.643 | *Reddingite* | Phos. | 010 ⊥ Y. $Z=c$ | $2V=41°$. Brown: X<Z | 124 |
| | 1.65 | 1.65 | 1.62 | *Friedelite* | Sil. | 0001 ⊥ X | $2V=0°\pm$. Pink± | 408 |
| | 1.65 | 1.66 | 1.64 | **Allanite** | Sil. | $Y=b$ | 2V = Lg. Green: X<Z | 316 |
| | 1.65 | | Very weak | **Apatite (Cl)** | Phos. | $X=c$ | Colorless or X>Z | 128 |
| | 1.65 | | Very weak | Daphnite | Sil. | 001 ⊥ X± | $2V=0°\pm$. Green: X<Z | 285 |
| | 1.65 | | .01± | Thuringite | Sil. | 001 ⊥ X± | $2V=0°\pm$. Green: X<Z | 285 |
| | 1.65 | 1.658 | 1.629 | *Eosphorite* | Phos. | 100 ⊥ Y | $2V=40°$. Pleo. X>Z | 156 |
| 1.651 | | 1.670 | 1.635 | **Forsterite** | Sil. | 010 ⊥ X | $2V=85°$. Gel. HCl | 188 |
| | 1.652 | 1.675 | 1.612 | *Liroconite* | Phos. | $Z\wedge c=-25°$ | $X=b$. $2V=67°$. Blue | 157 |
| 1.653 | | 1.675 | 1.653 | *Plumbogummite* | Phos. | Gumlike | $2V=0°$. Yellow: X<Z | 153 |
| 1.653 | | 1.680 | 1.644 | *Messelite* | Phos. | One | 2V = Mod. G. = 3 | 128 |
| 1.653 | | 1.658 | 1.650 | **ENSTATITE** | Sil. | 110 at 88° | $X=a$; $Z=c$. $2V=31°–90°$ | 217 |
| | 1.653 | 1.670 | 1.625 | Datolite | Sil. | $Z\wedge c=4°$; $Y=b$ | $2V=74°$. Gel. HCl | 424 |
| 1.654 | | 1.670 | 1.654 | Phenakite | Sil. | $11\bar{2}0$; $Z=c$ | G. = 3.0. Insol. | 185 |
| 1.654 | | 1.703 | 1.654 | *Rhabdophanite* | Phos. | Z ‖ fib. | $2V=0°$. Sol. HCl | 139 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.654 | 1.660 | 1.651 | **Clinoenstatite** | Sil. | 110 at 88° | $Y=b$. $Z\wedge c=22°$. $2V=54°$ | 220 |
| 1.654 | 1.689 | 1.62 | *Cabrerite* | Phos. | 010⊥X | $Z\wedge c=33°$. $2V=90°\pm$ | 127 |
| 1.654 | 1.660 | 1.647 | *Hureaulite* | Phos. | 100; $X=b$ | $Z\wedge c=+75°$. $2V=74°$ Yellow: $X<Z$ | 124 |
| 1.654 | .015± | | Jadeite | Sil. | 110 at 87° | $Y=b$. $Z\wedge c=35°$. $2V=70°$ | 235 |
| 1.655 | 1.655 | 1.650 | *Wilkeite* | Sil. | $X=c$ | Hex. G.=3.23 | 440 |
| 1.655 | 1.655 | 1.63 | **Tourmaline (Mg)** | Sil. | $X=c$ | Colorless or brown: $X<Z$. Insol. | 301 |
| 1.655 | 1.671 | 1.651 | *Euclase* | Sil. | 010⊥Y | $Z\wedge c=+41°$. $2V=50°$ | 432 |
| 1.655 | 1.662 | 1.655 | *Uranochalcite* | Sul. | Z ǁ fib. | $2V$=Sm. Green: $X<Z$ | 117 |
| 1.656 | 1.660 | 1.652 | *Palaite* | Phos. | Mono. | $2V$=Lg. G.=3.2 | 124 |
| 1.656 | 1.683 | 1.651 | *Reddingite* | Phos. | 010⊥Y | $Z=c$. $2V=41°$ | 124 |
| 1.656 | 02± | | *Gastaldite* | Sil. | 110 at 56° | $Z\wedge c=6°\pm$. $2V=43°\pm$. G.=3.0–3.1 | 259 |
| 1.656 | 1.714 | 1.649 | *Natrochalcite* | Sul. | 001; $Y=b$ | $Z\wedge c=12°$. $2V=37°$. Gr. | 112 |
| 1.657 | 1 658 | 1.646 | *Seybertite* | Sil. | 001⊥X± | $2V$=Sm. Yellow: $X<Z$ | 286 |
| 1.657 | 1.684 | 1.640 | *Leucosphenite* | Sil. | 010⊥Z | $Y\wedge c=3°$. $2V=77°$ | 418 |
| 1.658 | 1 695 | 1 640 | *Veszelyite* | Phos. | Tric.? | $2V=71°$. Blue | 138 |
| 1.658 | 1.687 | 1.622 | *Annabergite* | Phos. | 010⊥X | $Z\wedge c=36°$. $2V=84°$ | 127 |
| 1.658 | 1.658 | 1.486 | **CALCITE** | Carb. | $10\bar{1}1$; $X=c$ | Efferv. HCl. G.=2.72 | 71 |
| 1.658 | 1.677 | 1.657 | **Sillimanite** | Sil. | 010⊥Y; $Z=c$ | $2V=30°$. Colorless or $X<Z$ | 200 |
| 1.66± | .02± | | **Pargasite** | Sil. | 110 at 56° | $Y=b$. $Z\wedge c=25°$. $2V=70°$. Colorless or $X<Z$ | 248 |
| 1.66± | .015± | | Jadeite | Sil. | 110 at 87° | $Z\wedge c=35°\pm$. $2V=75°\pm$. G.=3.4± | 235 |
| 1.66 | 1.670 | 1.655 | *Salmonsite* | Phos. | Two. Z ǁ fib. | $2V$=Lg. Yellow: $X<Z$ | 156 |
| 1.660 | 1 672 | 1.650 | *Triplite* | Phos. | 100. $Z\wedge a=42°$ | $2V$=Lg. Pink: $X>Z$ | 134 |
| 1.660 | 1 715 | 1.645 | *Planchéite* | Sil. | Z ǁ fib. | $2V$=Mod. Blue: $X<Z$ | 411 |
| 1.66 | Weak | | *Fermorite* | Phos. | $X=c$ | G.=3.5. Sol. HCl | 130 |
| 1.66 | 1.69 | 1.63 | *Stewartite* | Phos. | 010 | $2V$=Lg. Yellow: $X<Z$ | 128 |
| 1.660 | 1 675 | 1.640 | *Tilasite* | Phos. | $Z\wedge c=-30°$ | $X=b$. $2V=82°$ | 134 |
| 1.660 | 1.661 | 1.649 | *Xanthophyllite* | Sil. | 001⊥X± | $2V$=Sm. X=br., Z=gr. | 286 |
| 1.66 | 02± | | **Pigeonite** | Sil. | 110 at 87° | $Z\wedge c=35°\pm$. $2V$=Sm. Tinted± | 222 |
| 1.66 | Weak | | *Crossite* | Sil. | 110 at 56° | $X\wedge c=70°$. $2V$=Sm. Blue: $X<Z$ | 259 |
| 1.661 | 1.688 | 1.645 | *Leucosphenite* | Sil. | 010⊥Z | $Y\wedge c=3°$. $2V=77°$ | 418 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | − | $N_g$ or $N_g - N_p$ | $N_p$ | Mineral | Chem. | Cleavage Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.59 | | 1.597 | 1.584 | **Anthophyllite** | Sil. | 110 at 56° | Y = *b*. Z = *c*. 2V = 85° ± | 240 |
| | 1.59 | 1 59 | 1.555 | **BIOTITE** | Sil. | 001 ⊥ X. Y = *b* | 2V = 0°. Br. or gr.: X < Z | 272 |
| 1.62 | | 1.63 | 1.61 | Cummingtonite | Sil. | 110 at 55° | Z ∧ *c* = 15° ±. 2V = 90° ±. Yellow: X < Z | 243 |
| | 1.63 | .09 ± | | *Stilpnomelane* | Sil. | 001 ⊥ X ± | 2V = Sm Green or brown: X < Z | 435 |
| | 1.64 | .02 ± | | **HORNBLENDE** | Sil. | 110 at 56° | Y = *b*. Z ∧ *c* = 20° ±. 2V = 80° ± X = yellow, Z = green | 247 |
| | 1.64 | .03 ± | | **Tourmaline (Fe)** | Sil. | X = *c* | Brown, green, blue: X < Z | 301 |
| 1.64 | | Weak | | **Melilite** | Sil. | X or Z = *c* | Abnor. int. colors | 208 |
| 1.64 | | 1.654 | 1.642 | Mullite | Sil. | 010 ⊥ Y. Z = *c* | 2V = 50° ±. Pink ±: X < Z | 201 |
| | 1.65 | 1.65 | 1.62 | *Friedelite* | Sil. | 0001 ⊥ X | 2V = 0° ±. Pink ± | 408 |
| | 1.65 | 1.66 | 1.64 | **Allanite** | Sil. | Y = *b* | 2V = Lg. Green: X < Z | 316 |
| | 1.65 | Very weak | | **Apatite (Cl)** | Phos. | X = *c* | Colorless or X > Z | 128 |
| | 1.65 | Very weak | | Daphnite | Sil. | 001 ⊥ X ± | 2V = 0° ±. Green: X < Z | 285 |
| | 1.65 | .01 ± | | Thuringite | Sil. | 001 ⊥ X ± | 2V = 0° ±. Green: X < Z | 285 |
| | 1.65 | 1.658 | 1.629 | *Eosphorite* | Phos. | 100 ⊥ Y | 2V = 40°. Pleo.: X > Z | 156 |
| 1.651 | | 1.670 | 1.635 | **Forsterite** | Sil. | 010 ⊥ X | 2V = 85° ±. Gel. HCl | 188 |
| 1.653 | | 1.658 | 1.650 | **ENSTATITE** | Sil. | 110 at 88° | X = *a*. Z = *c*. 2V = 31°–90° | 217 |
| 1.654 | | 1.660 | 1.651 | **Clinoenstatite** | Sil. | 110 at 88° | Y = *b*. Z ∧ *c* = 22°. 2V = 54° | 220 |
| | 1.658 | 1.658 | 1.486 | **CALCITE** | Carb. | $10\bar{1}1$. X = *c* | Efferv. HCl. G. = 2.72 | 71 |
| 1.658 | | 1.677 | 1.657 | **Sillimanite** | Sil. | 010 ⊥ Y. Z = *c* | 2V = 30°. Colorless or X < Z | 200 |
| | 1.66 | .02 ± | | **Pigeonite** | Sil. | 110 at 87° | Z ∧ *c* = 35° ±. 2V = Sm. Tinted ± | 222 |
| | 1.66 | Weak | | *Crossite* | Sil. | 110 at 56° | X ∧ *c* = 70° ±. 2V = Sm. Blue: X < Z | 259 |
| 1.662 | | 1.671 | 1.658 | *Dickinsonite* | Phos. | 001 ⊥ Y ± | X = *b*. 2V = Mod. Green: X > Z | 122 |
| 1.662 | | 1.727 | 1.629 | *Lindackerite* | Sul. | 010 ⊥ Y | X ∧ *c* = 26°. 2V = 73.° Gr. | 121 |
| 1.662 | | ? | 1.645 | *Soddite* | Ox. | Y = *b*. Z = *c* | 2V = ? Yellow | 61 |
| 1.662 | | 1.699 | 1.626 | Erythrite | Arsen. | 010 ⊥ X | Z ∧ *c* = +32° 2V = 90° ± Pink: X < Z | 127 |
| | 1.662 | 1.668 | 1.651 | Monticellite | Sil. | X = *b*. Y = *a* | 2V = 75°. Gel. HCl | 187 |
| 1.663 | | ? | 1.652 | Clinohumite[1] | Sil. | 001; Z = *b* | 2V = 76°. Yellow: X < Y | 197 |
| | 1.664 | 1.664 | 1.629 | *Friedelite* | Sil. | 0001 ⊥ X | Also biax. Pink: X < Z | 408 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.664 | 1.666 | 1.516 | Strontianite | Carb. | 110 at 63° | X=*c*. Z=*a*. 2V=11° | 81 |
| 1.665 | Weak | | **Melilite** | Sil. | X or Z=*c* | Abn. int. colors | 208 |
| 1.665 | 1.669 | 1.642 | *Eosphorite* | Phos. | 100⊥Y | X=*b* 2V=40°. Pink: X<Z | 156 |
| 1.665 | .035 | | **Forsterite** | Sil. | 010⊥X | 2V=85°±. Gel. HCl | 188 |
| 1.665 | 1.676 | 1.660 | Spodumene | Sil. | 110 at 87° | Z∧*c*=+25°±. 2V=60°±. Green or lilac: X>Z | 236 |
| 1.665 | .035+ | | **CHRYSOL.(Olivine)** | Sil. | 010⊥X; 100⊥Z | 2V=90°±. Gel. HCl | 189 |
| 1.666 | 1.673 | 1.661 | *Johnstrupite* | Sil. | 100⊥Z± | 2V=70°. Lam. twin. | 423 |
| 1.666 | 1.669 | 1.643 | *Uranophane* | Sil. | One⊥X | Z ∥ fib. 2V=40°. Yellow: X<Z. Abn. int. colors | 441 |
| 1.666 | 1.673 | 1.663 | Lithiophilite | Phos. | 001⊥Y; 010⊥Z | 2V=60°±. Pink: X>Z | 149 |
| 1.667 | .001± | | **Apatite** (Cl) | Phos. | X=*c* | Colorless or X>Z | 128 |
| 1.667 | 1.673 | 1.662 | Boracite | Bor. | 111 | 2V=83°. Comp. twin. | 94 |
| 1.668 | 1.681 | 1.665 | *Rinkite* | Sil. | 100. X=*b* | Y∧*c*=−8°. 2V=43°. Yellow: X<Z | 423 |
| 1.667 | 1.667 | 1.490 | *Plumbocalcite* | Carb. | 1011 | X=*c* | 72 |
| 1.668 | 1.702 | 1.635 | *Symplesite* | Arsen. | 010⊥X | Z∧*c*=+32°. 2V=87°. Green: X>Z | 126 |
| 1.669 | 1.689 | 1.650 | *Ludlamite* | Phos. | 001. Y=*b* | Z∧*c*=−67°. 2V=82°. Green | 137 |
| 1.669 | 1.669 | 1.658 | *Gehlenite* | Sil. | X=*c* | G.=3. Gel. HCl | 209 |
| 1.67± | 1.682 | 1.661 | Mullite | Sil. | 010⊥Y. Z=*c* | 2V=50°. Pink±: X<Z | 201 |
| 1.67 | .01± | | **Clinoenstatite** | Sil. | 110 at 87° | Z∧*c*=25°±. 2V=50°±. G.=3.19 | 220 |
| 1.67 | 1.684 | 1.661 | **Sillimanite** | Sil. | 010⊥Y; Z=*c* | 2V=30°. Colorless or X<Z | 200 |
| 1.67 | Weak | | *Crossite* | Sil. | 110 at 56° | X∧*c*=70°±. 2V=Sm. Blue: X<Z | 259 |
| 1.67 | .014 | | *Lotrite* | Sil. | One; Y=*b*? | 2V=18°±. Green in mass | 433 |
| 1.670 | 1.689 | 1.670 | *Hinsdalite* | Sul. | 0001⊥Z | Also biax. G.=4.65 | 119 |
| 1.670 | .01 | | *Clinohedrite* | Sil. | 010⊥Z | Y∧*c*=−28°. 2V=Lg. | 413 |
| 1.670 | 1.670 | 1.582 | *Ekmannite* | Sil. | 001⊥X± | G.=2.79. Green: X<Z | 281 |
| 1.67± | 1.67 | 1.65 | *Strigovite* | Sil. | 001⊥X± | 2V=0°±. Green: X<Z | 437 |
| 1.670 | 1 670 | 1.657 | *Justite* | Sil. | X=*c* | Tet. In slags | 209 |
| 1.671 | 1.694 | 1.664 | **DIOPSIDE** | Sil. | 110 at 87° | Z∧*c*=39°. 2V=60°. Insol. | 224 |
| 1.671 | 1.691 | 1.662 | *Manganandalusite* | Sil. | 110 at 89° | X=*a*. Z=*c*. 2V=71°. X=yellow, Y=green | 202 |
| 1.671 | ? | ? | *Uranotile* | Sil. | 100⊥X | 2V=? Yellow | 441 |
| 1.671 | 1.672 | 1.526 | *Alstonite* | Carb. | 010⊥Y? | 2V=7° | 79 |

[1] E. S. Larsen: *Am. Mineral.*, XIII, 1928, p. 354, gives $N_m$ as low as 1.638 for clinohumite.

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ or $N_g-N_p$ | $N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.59 | | 1.597 | 1.584 | **Anthophyllite** | Sil. | 110 at 56° | Y=*b*. Z=*c*. 2V=85°± | 240 |
| | 1.59 | 1.59 | 1.555 | **BIOTITE** | Sil. | 001 ⊥ X. | Y=*b*. 2V=0°. Brown or green: X<Z | 272 |
| 1.62 | | 1.63 | 1.61 | Cummingtonite | Sil. | 110 at 55° | Z∧*c*=15°±. 2V=90°±. Yellow: X<Z | 243 |
| | 1.63 | .09± | | *Stilpnomelane* | Sil. | 001 ⊥ X± | 2V=Sm. Green or brown: X<Z | 435 |
| | 1.64 | .02± | | **HORNBLENDE** | Sil. | 110 at 56° | Y=*b*. Z∧*c*=20°±. 2V=80°±. X=yellow, Z=green | 247 |
| | 1.64 | .03± | | **Tourmaline (Fe)** | Sil. | X=*c* | Brown, green, blue: X<Z | 301 |
| | 1.65 | 1.66 | 1.64 | **Allanite** | Sil. | Y=*b* | 2V=Lg. Green: X<Z | 316 |
| | 1.65 | Very weak | | Daphnite | Sil. | 001 ⊥ X± | 2V=0°±. Green: X<Z | 285 |
| | 1.65 | .01± | | Thuringite | Sil. | 001 ⊥ X± | 2V=0°±. Green: X<Z | 285 |
| 1.653 | | 1.658 | 1.650 | **ENSTATITE** | Sil. | 110 at 88° | X=*a*. Z=*c*. 2V=31°–90° | 217 |
| | 1.658 | 1.658 | 1.486 | **CALCITE** | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl. G.=2.72 | 71 |
| | 1.66 | .02± | | **Pigeonite** | Sil. | 110 at 87° | Z∧*c*=35°±. 2V=Sm. Tinted± | 222 |
| 1.663 | | ? | 1.652 | Clinohumite | Sil. | 001. Z=*b* | 2V=76. Yellow: X<Y | 197 |
| | 1.665 | .035+ | | **CHRYSOL.(Olivine)** | Sil. | 010 ⊥ X; 100 ⊥ Z | 2V=90°±. Gel. HCl | 189 |
| 1.666 | | 1.673 | 1.663 | Lithiophilite | Phos. | 001 ⊥ Y; 010 ⊥ Z | 2V=60°±. Pink: X>Z | 149 |
| 1.669 | | 1.689 | 1.650 | *Ludlamite* | Phos. | 001. Y=*b* | Z∧*c*=−67°. 2V=82°. Green | 137 |
| 1.67 | | 1.694 | 1.664 | **DIOPSIDE** | Sil. | 110 at 87° | Z∧*c*=39°. 2V=60°. Insol. | 224 |
| 1.672 | | 1.676 | 1.672 | *Fillowite* | Phos. | 001 | 2V=Sm. Sol. HCl | 123 |
| 1.672 | | 1.771 | 1.672 | *Parisite* | Carb. | 0001 ⊥ Z | Colorless or yellow: X<Z. Efferv. HCl | 85 |
| | 1.672 | 1.672 | 1.661 | *Hardystonite* | Sil. | 001 ⊥ X | G.=3.4. Gel. HCl | 209 |
| 1.673 | | 1.682 | 1.665 | *Triplite* | Phos. | 100; Y=*b* | Z∧*a*=42°. 2V=Lg. Pink: X>Z | 134 |
| 1.673 | | 1.698 | 1.664 | Clinohumite | Sil. | 001; Z=*b* | 2V=70°. Yellow: X>Y | 197 |
| | 1.673 | 1.685 | 1.634 | *Durangite* | Arsen. | 110 at 70° | X∧*c*=−25°. Z=*b*. 2V=57°. Yellow: X>Z. | 151 |
| | 1.673 | 1.674 | 1.661 | *Kornerupine* | Sil. | 110 at 81° | X=*c*; Y=*a*. 2V=20°. Colorless or X=yellow, Z=green | 421 |
| 1.674 | | 1.684 | 1.665 | Lawsonite | Sil. | 010 ⊥ Y; 001 ⊥ Z | 2V=84°. Blue±: X>Z | 430 |
| 1.674± | | 1.688 | 1.666 | *Jadeite-diopside* | Sil. | 110 at 87° | Y=*b*. Z∧*c*=45°. 2V=75° | 235 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1.674** | 1.684 | 1.671 | *Natrophilite* | Phos. | 001⊥Y; 010⊥Z | 2V=72°. Yellow | 150 |
| **1.674** | 1.699 | 1.663 | *Spodiosite* | Phos. | 010 | 2V=69°. Sol. HCl | 135 |
| 1.674 | 1.676 | 1.662 | *Bustamite* | Sil. | 010, 110, 1$\bar{1}$0 | X⊥010±. 2V=44° | 406 |
| 1.674 | 1.679 | 1.640 | *Spurrite* | Sil. | 001⊥Y± | 2V=40°. Lam. twin. | 442 |
| 1.675 | 1.684 | 1.665 | **HORNBLENDE** | Sil. | 110 at 56° | Y=*b*. Z∧*c*=20°±. 2V=80°±. X=yellow, Z=green | 247 |
| **1.675** | 1.697 | 1.653 | *Ludlamite* | Phos. | 001. Y=*b* | Z∧*c*=−67°. 2V=82°±. Green | 137 |
| **1.675** | 1.689 | 1.661 | *Liskeardite* | Arsen. | 010⊥X | 2V=Lg. G.=3. Insol. | 142 |
| 1.675 | 1.675 | 1.59 | *Chloromagnesite* | Hal. | 0001 Lam. | Deliques. | 32 |
| 1.675 | 1.675 | 1.636 | *Pyrosmalite* | Sil. | 0001⊥X | Green±; X<Z | 408 |
| 1.676 | 1.677 | 1.529 | Witherite | Carb. | 010⊥Y. X=*c* | 2V=16°. Ps. Hex. twin. | 81 |
| 1.677 | 1.677 | 1.665 | *Kornerupine* | Sil. | 110 at 81° | X=*c*. Y=*a*. 2V=20°. Colorless or X=yellow, Z=green | 421 |
| **1.678** | 1.702 | 1.669 | *Titanclinohumite* | Sil. | X∧*a*=−8° | Z=*b*. 2E=120°. Gel. HCl | 198 |
| 1.678 | 1.684 | 1.643 | *Childrenite* | Phos. | X=*b*; Y=*a* | 2V=45°. G.=3.2. Sol. HCl | 155 |
| 1.679 | 1.679 | 1.502 | **DOLOMITE (Mg)** | Carb. | 10$\bar{1}$1. X=*c* | G.=2.87. Efferv. HCl | 73 |
| **1.68** | .01± | | **ENSTATITE** | Sil. | 110 at 88° | X=*a*; Z=*c*. 2V=90°± | 217 |
| **1.68** | 1.70 | 1.66 | Cummingtonite | Sil. | 110 at 55° | Y=*b*. Z∧*c*=15°. 2V=80°± | 243 |
| 1.68 | Very weak | | Daphnite | Sil. | 001⊥X± | 2V=Sm. Green: X<Z | 285 |
| 1.68 | .01± | | Thuringite | Sil. | 001⊥X± | 2V=Sm. Green: X<Z | 285 |
| **1.68** | 1.683 | 1.678 | *Harstigite* | Sil. | X=*c*; Y=*b* | 2V=52°. G.=3.05 | 432 |
| **1.680** | 1.685 | 1.680 | *Florencite* | Phos. | 0001⊥Z | Yellow±. G.=3.59 | 142 |
| 1.68? | Strong | | *Erythrosiderite* | Hal. | X=*a*. Y=*c* | Yellow. Deliques. | 35 |
| 1.680 | 1.720 | 1.620 | *Zippeite* | Sul. | 010⊥X | Z∧*c*=35°±. 2V=Lg. Yellow: X<Z | 110 |
| 1.68 | Strong | | **OXYHORNBLENDE** | Sil. | 110 at 56° | Z∧*c*=Sm. 2V=80°±. Brown: X<Z | 252 |
| 1.68 | .012± | | **HYPERSTHENE** | Sil. | 110 at 88° | X=*a*; Z=*c*. 2V=80°±. X=reddish, Z=greenish | 219 |
| 1.68 | 1.70 | 1.66 | Grunerite | Sil. | 110 at 56° | Z∧*c*=15°±. 2V=80°±. Brown: X<Z | 242 |
| 1.681 | 1.683 | 1.667 | *Cenosite* | Sil. | One | 2V=Mod. Yellow | 440 |
| 1.681 | 1.685 | 1.530 | **Aragonite** | Carb. | 010, 110 | X=*c*; Z=*b*. 2V=18°. Efferv. HCl | 79 |
| 1.682± | 1.684 | 1.671 | *Prismatine* | Sil. | 110 at 81° | X=*c*. 2V=Sm. Yellow: X>Z | 421 |
| **1.683** | 1.717 | 1.662 | *Koettigite* | Arsen. | 010⊥X | Z∧*c*=37°. 2V=77°. Red | 127 |
| 1.683± | 1.70 | 1.61 | *Roscoelite* | Sil. | 001⊥X± | 2V=Sm. Olive-green: X<Z | 270 |
| 1.684 | 1.686 | 1.525 | *Barytocalcite* | Carb. | 110 at 73° | Z=*b*. X∧*c*=64°. 2V=15°. | 82 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ (or $N_g-N_p$) | $N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.59 | | 1.597 | 1.584 | **Anthophyllite** | Sil. | 110 at 56° | $Y=b$. $Z=c$. $2V=85°\pm$ | 240 |
| | 1.59 | 1.59 | 1.555 | **BIOTITE** | Sil. | 001 ⊥ X | $Y=b$. $2V=0$. Brown or green: X<Z | 272 |
| | 1.63 | .09± | | *Stilpnomelane* | Sil. | 001 ⊥ X± | 2V = Sm. Green or brown: X<Z | 435 |
| | 1.64 | .03± | | **Tourmaline (Fe)** | Sil. | $X=c$ | Brown, green, blue: X<Z | 301 |
| | 1.65 | 1.66 | 1.64 | **Allanite** | Sil. | $Y=b$ | 2V = Lg. Green: X<Z | 316 |
| | 1.658 | 1.658 | 1.486 | **CALCITE** | Carb. | $10\bar{1}1$. $X=c$ | Efferv. HCl. G. = 2.72 | 71 |
| | 1.66 | .02± | | **Pigeonite** | Sil. | 110 at 87° | $Z\wedge c=35°\pm$. 2V = Sm. Tinted ± | 222 |
| 1.665 | | .035+ | | **CHRYSOL. (Olivine)** | Sil. | 010 ⊥ X; 100 ⊥ Z | 2V = 90° ±. Gel. HCl | 189 |
| 1.666 | | 1.673 | 1.663 | Lithiophilite | Phos. | 001 ⊥ Y; 010 ⊥ Z | 2V = 60° ±. Pink: X>Z | 149 |
| 1.671 | | 1.694 | 1.664 | **DIOPSIDE** | Sil. | 110 at 87° | $Y=b$. $Z\wedge c=39°$. $2V=60°$ | 224 |
| | 1.679 | 1.679 | 1.502 | **DOLOMITE (Mg)** | Carb. | $10\bar{1}1$. $X=c$ | Efferv. HCl. G. = 2.87 | 73 |
| | 1.680 | 1.720 | 1.620 | *Zippeite* | Sul. | 010 ⊥ X | $Z\wedge c=35°\pm$. 2V = Lg. Yellow: X<Z | 110 |
| | 1.68 | Strong | | **OXYHORNBLENDE** | Sil. | 110 at 56° | $Z\wedge c$ = Sm. $2V=80°\pm$. Brown: X<Z | 252 |
| | 1.68 | .012± | | **HYPERSTHENE** | Sil. | 110 at 88° | $X=a$. $Z=c$. $2V=80°\pm$. X = reddish, Z = greenish | 219 |
| | 1.68 | 1.70 | 1.66 | Grunerite | Sil. | 110 at 56° | $Z\wedge c=15°\pm$. $2V=80°\pm$. Brown: X<Z | 242 |
| | 1.684 | 1.686 | 1.659 | Dumortierite | Sil. | 100 ⊥ Z | 2V = 30° ±. Blue, etc. X>Z | 422 |
| 1.685 | | .01± | | Lithiophilite | Phos. | 001 ⊥ Y; 010 ⊥ Z | 2V = 40° ±. Pink: X>Z | 149 |
| | 1.685 | 1.689 | 1.679 | **Axinite** | Sil. | $\bar{1}12$, 010 | 2V = 73° ±. X, Z = yellow, Y = violet | 425 |
| 1.685 | | 1.695 | 1.681 | *Barylite* | Sil. | 001 ⊥ Z | 2V = 65°. G. = 4 | 401 |
| 1.685 | | .01± | | Triphylite | Phos. | 001 ⊥ Y or X | 2V = Var. Sol. HCl | 149 |
| 1 686 | | 1.698 | 1.681 | *Titano-elpidite* | Sil. | 110 | $X=b$. $Y=c$. 2V = Mod. | 400 |
| | 1.686 | 1.698 | 1.67 | *Trichalcite* | Arsen. | Y ‖ elong. | 2V = Lg. Blue-green | 124 |
| 1.687 | | 1.711 | 1.682 | *Rosenbuschite* | Sil. | 001 | $X=b$. $Z\wedge c=-13°$. $2V=60°$. Yellow: X<Z | 419 |
| 1.687 | | 1.709 | 1.680 | Aegirinaugite | Sil. | 110 at 87° | $Z\wedge c=65°\pm$. $2V=65°\pm$. X = green, Z = yellow | 232 |
| | 1.687± | Weak | | **Riebeckite** | Sil. | 110 at 56° | $X\wedge c$ = Sm. 2V = Lg. X = blue, Z = green | 257 |
| | 1.687 | 1 690 | 1.658 | *Shroeckingerite* | Carb. | 010 ⊥ X | 2V = 40°. Yellow: X<Z | 86 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.69 | 1.69 | 1.60± | *Stilpnomelane* | Sil. | 001⊥X± | 2V = Sm. Brown to green: X<Z | 435 |
| 1.69 | 1.70 | 1.68 | **Anthophyllite** | Sil. | 110 at 54° | Y = *b*; Z = *c*. 2V = Lg. Insol. | 240 |
| 1.69 | 1.69 | 1.52± | *Manganocalcite* | Carb. | 10$\bar{1}$1. X = *c* | Efferv. HCl | 72 |
| 1.69 | 1.69 | 1.66 | **Tourmaline (Fe)** | Sil. | X = *c* | X<Z. Insol. | 301 |
| 1.69± | 1.701 | 1.680 | Barkevikite | Sil. | 110 at 56° | Z∧*c* = 12°±. 2V = 40°±. Brown: X<Z | 254 |
| 1.69 | 1.710 | 1.682 | *Jeffersonite* | Sil. | 110 at 87° | Z∧*c* = 54°. 2V = Lg. Brown | 228 |
| 1.690 | 1.693 | 1.675 | *Sincosite* | Phos. | 001⊥X | Also biax. Green: X<Z | 147 |
| 1.690 | 1.697 | 1.682 | *Chlorophoenicite* | Arsen. | 100⊥Opt. Ax. | 2V = 83°. Green-red | 134 |
| 1.69 | 1.71 | 1.685 | **AUGITE** | Sil. | 110 at 87° | Z∧*c* = 45°±. 2V = 60°±. Tinted± | 228 |
| 1.69 | .005± | | Arfvedsonite | Sil. | 110 at 56° | X∧*c* = Sm. Z = *b*. 2V = Lg. X = blue-green, Z = gray | 257 |
| 1.691 | 1.692 | 1.670 | Dumortierite | Sil. | 100⊥Z | 2V = 30°. Blue, etc. X>Z | 422 |
| 1.691 | Very weak | | *Fuggerite* | Sil. | 001⊥X | Tet. Abn. int. colors | 210 |
| 1.693 | .005 | | *Pharmacosiderite* | Phos. | Y = *b*? | 2V = Sm. Comp. twin. | 143 |
| 1.694± | 1.723 | 1.694 | Willemite | Sil. | 0001⊥Z | G. = 4±. Gel. HCl | 186 |
| 1.694 | 1.694 | 1.641 | *Spangolite* | Sul. | 0001⊥X | X = bluish green, Z = gr. | 119 |
| ..695 | 1.697 | 1.693 | **Riebeckite** | Sil. | 110 at 56° | X∧*c* = Sm. 2V = Lg. X = blue, Z = green | 257 |
| 1.695± | .012 | | *Guarinite* | Sil. | 110 at 90°± | 2V = 90°±. Yellow, pleo. | 406 |
| 1.695 | 1.698 | 1.684 | *Kempite* | Hal. | X = *c*; Y = *b* | 2V = Mod. Green | 39 |
| 1.696 | 1.703 | 1.691 | *Barylite* | Sil. | 001⊥Z | 2V = 81°. G. = 4 | 401 |
| 1.696 | 1.702 | 1.696 | **Zoisite** | Sil. | 010⊥Y or X | 2V = Sm. Abn. int. colors | 311 |
| 1.698 | 1.733 | 1.695 | *Euchroite* | Phos. | X = *b*; Y = *a* | 2V = 29°. Green | 136 |
| 1.698 | 1.706 | 1.660 | *Schroeckingerite* | Carb. | 010⊥X | 2V = 57°. Yellow: X<Z | 86 |
| 1.70 | 1.70 | 1.62 | **BIOTITE** | Sil. | 001⊥X± | 2V = 0°±. Brown: X<Z | 272 |
| 1.70 | .02 | | **Pigeonite** | Sil. | 110 at 87° | Z∧*c* = 35°±. 2V = Sm. Tinted± | 222 |
| 1.70 | 1.72 | 1.695 | **DIOPSIDE** | Sil. | 110 at 87° | Z∧*c* = 42°±. 2V = 60°±. Insol. | 224 |
| 1.70 | 1.70 | 1.52 | **DOLOMITE (Mg)** | Carb. | 10$\bar{1}$1. X = *c* | Efferv. HCl | 73 |
| 1.70 | 1.72 | 1.68 | **CHRYSOL.(Olivine)** | Sil. | 010⊥X; 100⊥Z | 2V = 85°±. Gel. HCl | 189 |
| 1.70 | 1.720 | 1.630 | *Zippeite* | Sul. | 010⊥X | Z∧*c* = 35°±. 2V = Lg. Yellow: X<Z | 110 |
| 1.700 | 1.736 | 1.690 | *Neptunite* | Sil. | 110 at 80° | Z∧*c* = 20°±. 2V = 49°. Red: X<Z | 418 |

* A. F. Buddington: *Amer. Jour. Sci.* cciii, 1922, p. 74.

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g - N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.65 | 1.66 | 1.64 | **Allanite** | Sil. | Y = *b* | 2V = Lg. Green: X<Z | 316 |
| | 1.68 | Strong | | **OXYHORNBLENDE** | Sil. | 110 at 56° | $Z \wedge c$ = Sm. 2V = 80° ±. Brown: X<Z | 252 |
| | 1.68 | .012± | | **HYPERSTHENE** | Sil. | 110 at 88° | X = *a*, Z = *c*. 2V = 90° ±. X = reddish, Z = greenish | 219 |
| | 1.68 | 1.70 | 1.66 | Grunerite | Sil. | 110 at 56° | $Z \wedge c$ = 15° ±. 2V = 80° ±. Brown: X<Z | 242 |
| 1.685 | | .01± | | Triphylite | Phos. | 001 ⊥ Y or X | 2V = Var. Sol. HCl | 149 |
| 1.687 | | 1.709 | 1.680 | Aegirinaugite | Sil. | 110 at 87° | $Z \wedge c$ = 65° ±. 2V = 65° ±. X = green, Z = yellow | 232 |
| 1.69 | | 1.71 | 1.685 | **AUGITE** | Sil. | 110 at 87° | $Z \wedge c$ = 45° ±. 2V = 60°. Tinted ± | 228 |
| 1.69 | | .005± | | Arfvedsonite | Sil. | 110 at 56° | $X \wedge c$ = Sm. Z = *b*. 2V = Lg. X = blue-green, Z = gray | 257 |
| 1.696 | | 1.702 | 1.696 | **Zoisite** | Sil. | 010 ⊥ Y or X | 2V = Sm. Abn. int. colors | 311 |
| 1.7± | | .012 | | *Hainite* | Sil. | 010 ⊥ Z ± | 2V = Lg. Yellow: X<Z | 406 |
| 1.700 | | 1.708 | 1.698 | *Pumpellyite* | Sil. | 010 ⊥ X | Y = *b*. Green: X<Y | 432 |
| | 1.700 | 1.735 | 1.625 | *Ancylite* | Carb. | X = *a*; Z = *c* | 2V = 66°. Green, etc. | 87 |
| | 1.70+ | 1.712 | 1.639 | *Sussexite* | Bor. | X ‖ fib. | 2V = Sm. G. = 3.1 | 91 |
| | 1.70 | 1.700 | 1.509 | Magnesite | Carb. | $10\bar{1}1$. X = *c* | Efferv. HCl. G. = 2.96 | 75 |
| | 1.70 | 1.72 | 1.695 | **Salite** | Sil. | 110 at 87° | $Z \wedge c$ = 42° ±. 2V = 60° ±. Insol. | 227 |
| | 1.70 | 1.70 | 1.52 | Ankerite | Carb. | $10\bar{1}1$. X = *c* | Efferv. HCl. G. = 3 ± | 73 |
| | 1.70 | 1.72 | 1.68 | Hyalosiderite | Sil. | 010 ⊥ X; 100 ⊥ Z | 2V = 80° ±. Gel. HCl | 189 |
| | 1.701 | 1.704 | 1.693 | *Tinzenite* | Sil. | 100 ⊥ X ± | 2V = 63°. Green: X>Z | 428 |
| 1.702 | | 1.706 | 1.700 | **Zoisite** | Sil. | 010 ⊥ Y or X | 2V = Sm. Colorless or X = pink, Z = yellow | 311 |
| 1.703 | | 1.733 | 1.678 | *Astrophyllite* | Sil. | 010 ⊥ X | 2V = 75°. Yellow: X>Z | 417 |
| 1.703 | | 1.706 | 1.701 | *Serendibite* | Sil. | None | 2V = 90° ±. X = yellow, Z = blue | 425 |
| | 1.704 | 1.704 | 1.679 | *Schallerite* | Sil.+ | One ⊥ X | 2V = 0°. G. = 3.37 | 440 |
| | 1.705 | 1.705 | 1.701 | Vesuvianite | Sil. | 110 at 90° | 2V = 0°. Colored ± | 207 |
| 1.705 | | 1.724 | 1.700 | *Graftonite* | Phos. | X = *b* | 2V = 55° ±. G. = 3.67 | 122 |
| | 1.705 | 1.713 | 1.660 | *Tarbuttite* | Phos. | 001 | 2V = 50°. Sol. HCl | 135 |
| | 1.706 | 1.706 | 1.698 | *Svabite* | Arsen. | X = *c* | 2V = 0°. Sol. HCl | 129 |
| | 1.707 | 1.708 | 1.704 | *Sapphirine* | Sil. | $Z \wedge c$ = 10° ± | Y = *b*. 2V = 69°. Blue: X<Z | 427 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.707 | 1.707 | 1.517 | *Breunnerite* | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 75 |
| 1.708 | 1.745 | 1.708 | *Strengite* | Phos. | 001⊥Z | 2V=Sm. Pink±: X<Z | 140 |
| 1.71+ | 1.71 | 1.70 | Triphylite | Phos. | 001⊥X | 2V=Sm. Sol. HCl | 149 |
| 1.71 | .025± | | **AUGITE** | Sil. | 110 at 87° | Z∧*c*=45°±. 2V=60°. Tinted±: X<Y | 228 |
| 1.71 | .01± | | **Allanite?** | Sil. | ? | 2V=Lg. Brown: X<Z | 316 |
| 1.71 | 1.71 | 1.52 | Magnesite | Carb. | 10$\bar{1}$1 | Efferv. HCl | 75 |
| 1.71 | .005± | | Arfvedsonite | Sil. | 110 at 56° | X∧*c*=10°±. Z=*b*. 2V=Lg. Blue: X>Z | 257 |
| 1.71± | .04± | | Grunerite | Sil. | 110 at 56° | Z∧*c*=15°±. 2V=80°±. Green to brown: X<Z | 242 |
| 1.71 | .01± | | *Stibiconite* | Ox. | ? | G.=5.2±. Insol. | 68 |
| 1.711 | 1.718 | 1.708 | *Merwinite* | Sil. | 010⊥Z | X∧*c*=36°. 2V=67°. Gel. HCl | 194 |
| 1.711 | 1.724 | 1.709 | *Brandtite* | Arsen. | 010⊥X | Y∧*c*=+7°. 2V=23°. Sol. HCl | 125 |
| 1.712 | Strong | | *Palmierite* | Sul. | Hex. | G.=4.5. Sol. $HNO_3$ | 110 |
| 1.713 | 1.722 | 1.703 | *Gerhardtite* | Nit. | 001⊥Z; 100⊥X | 2V=Lg. X=gr., Z=blue | 89 |
| 1.714 | 1.735 | 1.690 | *Schoepite* | Ox. | 001⊥X | 2V=Lg. Yellow: X<Z | 60 |
| 1.715± | 1.73 | 1.713 | **Clinohypersthene** | Sil. | 110 at 87° | Z∧*c*=30°±. 2V=30°±. G.=3.4± | 221 |
| 1.715 | Weak | | **Clinozoisite** | Sil. | 001. X∧*c*=Sm. | 2V=Lg. Tinted±: X<Z | 312 |
| 1.715 | 1.718 | 1.674 | Iddingsite | Sil. | 100⊥X; 001⊥Z | 2V=Var. Brown: X<Z | 437 |
| 1.716± | Weak | | *Viluite* | Sil. | Z=*c* | G.=3.4±. Tinted± | 207 |
| 1.716 | 1.726 | 1.700 | *Woehlerite* | Sil. | 010⊥Z | X∧*c*=−45°. 2V=75°±. Yellow: X<Z | 441 |
| 1.716 | 1.729 | 1.679 | *Glaucochroite* | Sil. | X=*b*; Y=*c* | 2V=61°. Gel. HCl | 187 |
| 1.717 | 1.818 | 1.717 | *Bastnäsite* | Carb. | Z=*c* | G.=5.0. Efferv. HCl | 85 |
| 1.718 | 1.733 | 1.715 | *Magnesium-orthite* | Sil. | Poor | 2V=50°. Brown | 317 |
| 1.719 | 1.719 | 1.527 | *Mesitite* | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 75 |
| 1.72 | 1.735 | 1.71 | **Salite** | Sil. | 110 at 87° | Z∧*c*=45°. 2V=60°. Tinted± | 227 |
| 1.72 | .015± | | **HYPERSTHENE** | Sil. | 110 at 88° | X=*a*; Z=*c*. 2V=65°±. X=reddish, Z=greenish | 219 |
| 1.720 | 1.725 | 1.715 | *Trimerite* | Sil. | 001⊥X± | 2V=83°. Sol. HCl | 401 |
| 1.720 | 1.720 | 1.691 | *Phosphuranylite* | Phos. | 010⊥X | 2V=0°±. Yellow: X<Z | 147 |
| 1.72 | 1.72 | 1.53 | Mangandolomite | Carb. | 10$\bar{1}$1. X=*c* | G=3.3±. Efferv. HCl | 73 |
| 1.721 | 1.816 | 1.721 | Xenotime | Phos. | 110 at 90° | G.=4.59. Insol. | 138 |
| 1.721 | 1.731 | 1.712 | *Adelite* | Arsen. | Y=*b* | Z∧*c*=+39°. 2V=Lg. G.=3.75 | 134 |
| 1.722 | 1.735 | 1.686 | *Glaucochroite* | Sil. | X=*b*. Y=*c* | 2V=61°. Gel. HCl | 187 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g - N_p$) | Mineral | Chem. | Cleavage Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.65 | 1.66 | 1.64 | **Allanite** | Sil. | Y=*b* | 2V=Lg. Green: X<Z | 316 |
| | 1.68 | Strong | | **OXYHORNBLENDE** | Sil. | 110 at 56° | Z∧*c*=Sm. 2V=80°±. Brown: X<Z | 252 |
| 1.687 | | 1.709 | 1.680 | Aegirinaugite | Sil. | 110 at 87° | Z∧*c*=65°±. 2V=65°±. X=green, Z=yellow | 232 |
| | 1.70 | 1.70 | 1.52 | Ankerite | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl. G.=3± | 73 |
| | 1.70 | 1.72 | 1.68 | Hyalosiderite | Sil. | 010⊥X. 100⊥Z | 2V=85°±. Gel. HCl | 189 |
| | 1.705 | 1.705 | 1.701 | Vesuvianite | Sil. | 110 at 90° | 2V=0°. Colored± | 207 |
| | 1.707 | 1.708 | 1.704 | *Sapphirine* | Sil. | Z∧*c*=10°± | Y=*b*. 2V=69°. Blue: X<Z | 427 |
| | 1.707 | 1.707 | 1.517 | *Breunnerite* | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 75 |
| 1.708 | | 1.745 | 1.708 | *Strengite* | Phos. | 001⊥Z | 2V=Sm. Pink±: X<Z | 140 |
| | 1.71 | .01± | | **Allanite?** | Sil. | ? | 2V=Lg. Brown: X<Z | 316 |
| 1.71 | | .01± | | *Stibiconite* | Ox. | ? | G.=5.2. Insol. | 68 |
| 1.715 | | Weak | | **Clinozoisite** | Sil. | 001. X∧*c*=Sm. | 2V=Lg. Tinted±: X<Z | 312 |
| | 1.715 | 1.718 | 1.674 | Iddingsite | Sil. | 100⊥X; 001⊥Z | 2V=Var. Brown: X<Z | 437 |
| | 1.719 | 1.719 | 1.527 | *Mesitite* | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 75 |
| | 1.72 | 1.72 | 1.53 | Mangandolomite | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl. G.=3.3± | 73 |
| 1.722 | | 1.824 | 1.722 | *Bastnäsite* | Carb. | Z=*c*. Hex. | G.=5.0. Efferv. HCl | 85 |
| 1.722 | | 1.750 | 1.702 | Diaspore | Ox. | 010⊥Y | 2V=84°. Colorless or red±: X>Z | 46 |
| | 1.722 | 1.729 | 1.717 | **Kyanite** | Sil. | 100⊥X± | 2V=83°. H=4 to 7.5 | 205 |
| 1.722 | | 1.731 | 1.720 | Chloritoid | Sil. | 001⊥Z± | 2V=Mod. X=gr., Y=bl. | 438 |
| | 1.723 | 1.723 | 1.681 | *Pyrochroite* | Ox. | 0001⊥X | Brown±: X<Z | 42 |
| 1.724 | | 1.746 | 1.724 | *Connellite* | Sul. | Z=*c* | G.=3.38. Blue | 118 |
| 1.725 | | 1.738 | 1.715 | *Homilite* | Sil. | Z=*b*. Y=*c*± | 2V=80°. Brown: Y>Z | 424 |
| 1.725 | | .01 | | *Roselite* | Arsen. | 100⊥X± | Tr. 2V=Mod. Red: X>Z | 127 |
| 1.725 | | Very weak | | *Sarcopsite* | Phos. | 001, 010 | Mon.? G.=3.64 | 134 |
| | 1.725 | 1.738 | 1.692 | *Phosphosiderite* | Phos. | 010⊥Y | X∧*c*=4°. 2V=62°. Red±: Y>Z | 142 |
| 1.726 | | 1.746 | 1.713 | Babingtonite | Sil. | 1$\bar{1}$0, 110 | 2V=60°. X=gr., Y=br. | 428 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.726 | 1.730 | 1.725 | *Triploidite* | Phos. | 100. X=b | 2V=Mod. G.=3.7 | 134 |
| 1.726 | 1.730 | 1.694 | *Tyrolite* | Arsen. | 001⊥X | 2V=36°. Green: X>Y | 161 |
| 1.726 | 1.730 | 1.721 | Rhodonite | Sil. | 110, 1$\bar{1}$0, 001 | 2V=76°. G.=3.5± | 403 |
| 1.727± | 1.740 | 1.711 | *Picrotephroite* | Sil. | 001, 010 | 2V=85°. Gel. HCl | 194 |
| 1.728 | .05 | | *Adamite* | Arsen. | X=a. Y=c | 2V=83°. Pink± | 133 |
| 1.729 | 1.730 | 1.705 | *Ganophyllite* | Sil. | 001⊥X±; 010 | Z=b. 2V=24°. Brown: X>Z | 436 |
| 1.73 | 1.76 | 1.69 | **OXYHORNBLENDE** | Sil. | 110 at 56° | Z∧c=Sm. 2V=80°. Brown: X<Z | 252 |
| 1.73± | .01 | | *Ottrelite* | Sil. | 001⊥Z± | 2V=Var. X=gr., Y=bl. | 438 |
| 1.730 | 1.810 | 1.730 | *Mixite* | Arsen. | Z=c | 2V=Sm. Green | 156 |
| 1.73 | 1.73 | 1.72 | *Melanocerite* | Sil. | X=c | G.=4.13. Yellow | 420 |
| 1.73 | 1.745 | 1.725 | **Hedenbergite** | Sil. | 110 at 87° | Z∧c=45°. 2V=60°. Green: X<Z | 224 |
| 1.73 | 1.75 | 1.72 | *Piedmontite* | Sil. | 001. Y=b | 2V=70°. X=yel., Z=red | 315 |
| 1.731± | 1.748 | 1.720 | *Jeffersonite* | Sil. | 110 at 87° | Z∧c=54°. 2V=Mod. G.=3.5 | 228 |
| 1.731 | 1.732 | 1.710 | *Chalcomenite* | Sel. | Y=b (Li) | 2V=Sm. Sol. HCl | 118 |
| 1.732 | .05± | | *Phosphosiderite* | Phos. | 010⊥Y | X∧c=4°. 2V=62°. Red±: Y>Z | 142 |
| 1.732 | 1.762 | 1.730 | *Strengite* | Phos. | 001⊥Z | 2V=29°. Pink: X<Z | 140 |
| 1.733 | 1.734 | 1.729 | *Sapphirine* | Sil. | Z∧c=10°± | 2V=69°. Blue: X<Z | 427 |
| 1.733 | .04 | | *Pyrochroite* | Ox. | 0001⊥X | Brown±: X<Z | 42 |
| 1.733 | 1.733 | 1.714 | *Hematolite* | Phos. | 0001⊥X | Also biax. Yellow | 153 |
| 1.733 | 1.87 | 1.72 | *Ferrimolybdite* | Molyb. | 001⊥Z | 2V=28°. Yellow: X<Z | 108 |
| 1.734 | 2.07 | 1.557 | *Curtisite* | C,H,O | 001⊥Z | Y=b. 2V=83° | 18 |
| 1.734 | 1.758 | 1.708 | *Adamite* | Arsen. | X=a; Y=c | 2V=83°. Colorless or X>Z | 133 |
| 1.735 | .01± | | **Clinozoisite** | Sil. | 001; Y=b | 2V=Lg. Tinted±. X<Z | 312 |
| 1.735 | 1.758 | 1.735 | *Connellite* | Sul. | Z=c | Blue. Sol. HCl | 118 |
| 1.735 | 1.75 | 1.715 | *Hodgkinsonite* | Sil. | 001⊥Z± | 2V=Mod. Gel. HCl | 412 |
| 1.735 | 1.745 | 1.715 | *Sicklerite* | Phos. | One⊥Z | 2V=Lg. Yellow: X>Z | 158 |
| 1.735 | .03± | | **PISTAC. (Epidote)** | Sil. | 001; Y=b | 2V=Lg. Yellow: X<Y | 314 |
| 1.736 | 1.736 | 1.732 | Vesuvianite | Sil. | X=c | Also biax. G.=3.4 | 207 |
| 1.736± | 1.750 | 1.640 | *Hydrozincite* | Carb. | 100. X=b | 2V=40°. Efferv. HCl | 83 |
| 1.737 | 1.785 | 1.730 | *Antlerite* | Sul. | 010⊥X | 2V=35°. Green: X<Z | 102 |
| 1.738 | 1.746 | 1.718 | *Shannonite* | Sil. | 010⊥Z | 2V=64°. Sol. HCl | 195 |

## TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g-N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.65 | 1.66 | 1.64 | **Allanite** | Sil. | Y=*b* | 2V=Lg. Green: X<Z | 316 |
| 1.687 | | 1.709 | 1.680 | Aegirinaugite | Sil. | 110 at 87° | Z∧*c*=65°±. 2V=65°±. X=green, Z=yellow | 232 |
| | 1.70 | 1.70 | 1.52 | Ankerite | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl. G.=3± | 73 |
| | 1.70 | 1.72 | 1.68 | Hyalosiderite | Sil. | 010⊥X; 100⊥Z | 2V=85°±. Gel. HCl | 189 |
| | 1.707 | 1.707 | 1.517 | *Breunnerite* | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 75 |
| | 1.71 | .01± | | **Allanite?** | Sil. | ? | 2V=Lg. Brown: X<Z | 316 |
| 1.71 | | .01± | | *Stibiconite* | Ox. | ? | G.=5.2. Insol. | 68 |
| | 1.715 | 1.718 | 1.674 | Iddingsite | Sil. | 100⊥X; 001⊥Z | 2V=Var. Brown: X<Z | 437 |
| | 1.719 | 1.719 | 1.527 | *Mesitite* | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 75 |
| | 1.72 | 1.72 | 1.53 | Mangandolomite | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl. G.=3.3± | 73 |
| 1.722 | | 1.731 | 1.720 | Chloritoid | Sil. | 001⊥Z± | 2V=Mod. X=green, Y=blue | 438 |
| | 1.726 | 1.730 | 1.721 | Rhodonite | Sil. | 110, 1$\bar{1}$0, 001 | 2V=76°. G.=3.5± | 403 |
| 1.730 | | 1.810 | 1.730 | *Mixite* | Arsen. | Z=*c* | 2V=Sm. Green | 156 |
| 1.73 | | 1.745 | 1.725 | **Hedenbergite** | Sil. | 110 at 87° | Z∧*c*=45°±. 2V=60°. Green: X<Z | 224 |
| 1.73 | | 1.75 | 1.72 | *Piedmontite* | Sil. | 001. Y=*b* | 2V=70°. X=yel., Z=red | 315 |
| 1.733 | | 1.87 | 1.72 | *Ferrimolybdite* | Molyb. | 001⊥Z | 2V=28°. Yellow: X<Z | 108 |
| | 1.735 | .03± | | **PISTAC. (Epidote)** | Sil. | 001. Y=*b* | 2V=Lg. Yellow: X<Y | 314 |
| | 1.738 | 1.744 | 1.731 | *Thalenite* | Sil. | Y=*c*±; Z=*b* | 2V=70°±. G.=4.3± | 414 |
| 1.74 | | .03± | | Aegirinaugite | Sil. | 110 at 87° | X∧*c*=40°±. 2V=Lg. Green: X>Z | 232 |
| | 1.74 | 1.74 | 1.54 | Ankerite | Carb. | 10$\bar{1}$1. X=*c* | G.=3.1. Efferv. HCl | 73 |
| | 1.74 | 1.744 | 1.733 | Rhodonite | Sil. | 110, 1$\bar{1}$0, 001 | 2V=76°. G.=3.5 | 403 |
| 1.74± | | 1.775 | 1.735 | *Jadeite-acmite* | Sil. | 110 at 87° | X∧*c*=5°. 2V=Lg. | 193 |
| 1.74± | | .01 | | *Sismondine* | Sil. | 001⊥Z± | 2V=50°±. X=green, Y=blue | 438 |
| 1.74 | | 1.770 | 1.735 | *Molengraafite* | Sil. | 100⊥Y± | 2V=28°. Yellow: Y<Z | 244 |
| | 1.74± | Strong | | *Vilateite* | Phos. | Z=*c*? | 2V=Mod. Pink: X<Z | 140 |
| | 1.740 | 1.744 | 1.655 | *Aurichalcite* | Carb. | 100⊥Y± | 2V=Sm. Green: X<Z | 84 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.74+ | Strong | | *Melanovanadite* | Sul. | 010⊥X | 2V=Sm. Brown: X<Z | 102 |
| 1.74 | 1.74 | 1.54 | Ferrodolomite | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 73 |
| 1.741 | 1.746 | 1.736 | **Staurolite** | Sil. | 010⊥X | 2V=88°. Yellow: X<Z | 202 |
| 1.742 | 1.765 | 1.738 | Scorodite | Arsen. | X=*b*; Y=*a* | 2V=Mod. Green, pleo. | 139 |
| 1.745 | 1.757 | 1.739 | **Hedenbergite** | Sil. | 110 at 87° | Z∧*c*=48°. 2V=60°. Green: X<Z | 224 |
| 1.745 | 1.830 | 1.745 | *Mixite* | Arsen. | Z=*c* | 2V=Sm. Green | 155 |
| 1.745 | 1.789 | 1.702 | *Libethenite* | Phos. | X=*b*; Y=*c* | 2V=83°. Green: Y>Z | 132 |
| 1.748± | 1.755 | 1.745 | *Chrysoberyl* | Ox. | Y=*b*; Z=*c* | 2V=60°±. G.=3.64 | 65 |
| 1.748 | 1.748 | 1.645 | *Freirinite* | Phos. | 001⊥X | 2V=0°. Blue: X<Z | 151 |
| 1.75 | 1.77 | 1.72 | Hyalosiderite | Sil. | 010⊥X | 2V=80°. Gel. HCl | 189 |
| 1.75 | 1.75 | 1.55 | Mangandolomite | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl. G.=3.3 | 73 |
| 1.75 | 1.75 | 1.55 | *Breunnerite* | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 75 |
| 1.750 | .030± | | *Laavenite* | Sil. | 100 | X∧*c*=20°. 2V=80°. Yellow±: X<Z | 420 |
| 1.75 | 1.788 | 1.743 | *Lorenzenite* | Sil. | 120. Z=*b* | 2V=39°. Insol. | 400 |
| 1.75 | 1.80 | 1.72 | *Rutherfordite* | Carb. | ? | G.=4.8. Yellow± | 86 |
| 1.75 | 1.87± | 1.57 | *Hoelite* | H, C | X=*c*; Y=*a* | 2V=Sm. G.=1.43 | 18 |
| 1.754 | 1.762 | 1.747 | **Staurolite** | Sil. | 010⊥X | 2V=Lg. Golden: X<Z | 202 |
| 1.754 | 1.764 | 1.743 | *Caracolite* | Sul. | None | 2V=Lg. Ps. Hex. twin. | 120 |
| 1.755± | .01± | | *Pyroxmangite* | Sil. | 110 at 88° | Z∧*c*=45°. 2V=30°. Yellowish | 406 |
| 1.755 | 1.82 | 1.755 | *Vegasite* | Sul. | 10$\bar{1}$1. Z=*c* | Yellow: X<Z | 116 |
| 1.757 | 1.804 | 1.757 | *Benitoite* | Sil. | Z=*c* | Blue, etc. X<Z | 212 |
| 1.758 | 1.838 | 1.730 | Azurite | Carb. | 100⊥Y± | 2V=68°. Blue: X<Z | 82 |
| 1.76 | .02 | | **Allanite?** | Sil. | ? | Brown: X<Z | 316 |
| 1.76 | 1.81 | ? | *Glockerite* | Sul. | ? | Brown, green | 108 |
| 1.76 | 1.76 | 1.63 | *Chalcodite* | Sil. | 001⊥X± | 2V=Sm. X=yel, Z=br. | 435 |
| 1.76 | Strong | | *Cappelenite* | Sil. | X=*c* | Brown. Sol. HCl | 420 |
| 1.760 | 1.760 | 1.577 | *Cordylite* | Carb. | 0001⊥X | Colorless or yellow: X>Z | 86 |
| 1.760 | 1.798 | 1.708 | *Langite* | Sul. | 001⊥X | 2V=81°. Blue-gr.: X<Z | 102 |
| 1.762 | 1.805 | 1.719 | *Dihydrite* | Phos. | X∧*c*=+22° | 2V=90°±. Green: X>Z | 135 |
| 1.763 | ? | 1.762 | *Dewindtite* | Phos. | 100⊥X | 2V=Lg. Yellow | 148 |
| 1.763 | 1.768 | 1.724 | Iddingsite | Sil. | 100⊥X; 001⊥Z | 2V=40°±. Brown: X<Z | 437 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g-N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.65 | 1.66 | 1.64 | **Allanite** | Sil. | Y=*b* | 2V=Lg. Green: X<Z | 316 |
| 1.71 | | .01± | | *Stibiconite* | Ox. | ? | G.=5.2. Insol. | 68 |
| | 1.719 | 1.719 | 1.527 | *Mesitite* | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 75 |
| 1.722 | | 1.731 | 1.720 | Chloritoid | Sil. | 001⊥Z± | 2V=Mod. X=green, Y=blue | 438 |
| 1.73 | | 1.75 | 1.72 | *Piedmontite* | Sil. | 001. Y=*b* | 2V=70. X=yel., Z=red | 315 |
| 1.733 | | 1.87 | 1.72 | *Ferrimolybdite* | Molyb. | 001⊥Z | 2V=28°. Yellow: X<Z | 108 |
| | 1.735 | .03± | | **PISTAC. (Epidote)** | Sil. | 001. Y=*b* | 2V=Lg. Yellow: X<Y | 314 |
| | 1.74 | 1.74 | 1.54 | Ferrodolomite | Carb. | 10$\bar{1}$1. X=*c* | Efferv. HCl | 73 |
| 1.742 | | 1.765 | 1.738 | Scorodite | Arsen. | X=*b*. Y=*a* | 2V=Mod. Green: pleo. | 139 |
| | 1.76 | 1.76 | 1.63 | *Chalcodite* | Sil. | 001⊥X± | 2V=Sm. X=yel., Z=br. | 435 |
| | 1.768 | 1.768 | 1.760 | Corundum | Ox. | None. X=*c* | Tinted±: X<Z | 43 |
| 1.77 | | .016± | | Chloritoid | Sil. | 001⊥Z± | 2V=50°±. X=green, Y=blue | 438 |
| 1.77 | | 1.82 | 1.76 | *Piedmontite* | Sil. | 001; Y=*b* | 2V=55°±. Brown: X<Z | 315 |
| 1.77 | | .01 | | *Stibiconite* | Ox. | Z=*c* | G.=5.2. Insol. | 68 |
| | 1.77 | 1.78 | 1.73 | **PISTAC. (Epidote)** | Sil. | 001. Y=*b* | 2V=75°±. X, Z=greenish, Y=golden | 314 |
| | 1.77 | Strong | | *Nordenskioeldite* | Bor. | 001⊥X | Yellow± | 95 |
| 1.770 | | 1.785 | 1.698 | *Holdenite* | Phos. | Y=*b*. Z=*a* | 2V=30°. G.=4 | 136 |
| 1.77 | | 1.79 | 1.765 | *Conichalcite* | Arsen. | Z ‖ fib. | 2V=25°. X=yel., Z=gr. | 136 |
| | 1.77 | 1.782 | 1.745 | **Acmite** | Sil. | 110 at 87° | X∧c=5°±. 2V=69°±. Brown or green: X>Z | 234 |
| | 1.771 | 1.782 | 1.751 | *Leucophenicite* | Sil. | One⊥X | 2V=74°. Pink± | 412 |
| | 1.772 | 1.772 | 1.763 | Corundum | Ox. | X=*c* | Tinted±: X<Z | 43 |
| | 1.772 | 1.772 | 1.770 | *Swedenborgite* | Antim. | 0001⊥X | G.=4.29. Insol. | 149 |
| | 1.773 | 1.807 | 1.729 | *Margarosanite* | Sil. | 010. Tric. | 2V=83°. G.=4.0 | 406 |
| 1.774 | | 1.783 | 1.770 | *Barthite* | Arsen. | None | 2V=Mod. G.=4.2 | 160 |
| 1.774 | | 1.83 | 1.770 | *Taramellite* | Sil. | Z ‖ fib. | 2E=76°. Brown: X<Z | 427 |
| 1.776 | | 1.795 | 1.758 | *Orientite* | Sil. | X=*a*; Y=*c* | 2V=67°. Brown: X>Z | 432 |
| | 1.778 | 1.790 | 1.760 | *Leucophenicite* | Sil. | One⊥X | 2V=74°. Pink± | 412 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.778 | 1.803 | 1.730 | *Brochantite* | Sul. | 010 ⊥ X | Y = *a*. 2V = 72°. Gr.: X < Z | 102 |
| 1.78 | 1.80 | 1.77 | **Allanite** | Sil. | Y = *b* | 2V = Lg. Green: X < Z | 316 |
| 1.78 | 1.78 | 1.65 | *Chalcodite* | Sil. | 001 ⊥ X ± | 2V = Sm. Brown: X < Z | 435 |
| 1.78 | 1.78 | 1.57 | Ferrodolomite | Carb. | 10$\bar{1}$1. X = *c* | G. = 3.36 ±. Efferv. HCl | 73 |
| 1.78 | 1.801 | 1.778 | *Conichalcite* | Arsen. | Z ∥ fib. | 2V = Sm. X = yel., Z = gr. | 136 |
| 1.780 | 1.805 | 1.776 | *Caryinite* | Arsen. | 110 at 81°; 010 | Z = *b*. 2V = 41°. Brown ± | 122 |
| 1.78 ± | 1.785 | 1.772 | *Gadolinite* | Sil. | Z ∧ *c* = 10° ± | 2V = 85°. X < Z Brown or green: | 424 |
| 1.78 + | ? | ? | *Kasolite* | Sil. | 001; X = *b* | 2V = 39°. Yellow ± | 442 |
| 1.782 | 1.815 | 1.752 | *Shaituckite* | Sil. | Z ∥ fib. ± | 2V = Lg. Blue: X < Z | 411 |
| 1.785 | 1.79 | 1.58 | *Mesitite* | Carb. | 10$\bar{1}$1. X = *c* | G. = 3.1 ±. Efferv. HCl | 75 |
| 1.785 | 1.829 | 1.747 | *Olivenite* | Arsen. | X = *a*; Y = *c* | 2V = Lg. Green | 132 |
| 1.785 | 1.785 | 1.57 | *Pistomesite* | Carb. | 10$\bar{1}$1. X = *c* | G. = 3.4. Efferv. HCl | 75 |
| 1.786 | 1.815 | 1.775 | *Beraunite* | Phos. | 100; Z = *b* | 2V = Mod. Red: X < Z | 144 |
| 1.786 | 1.787 | 1.761 | *Allactite* | Arsen. | 010 ⊥ Z | 2V = 0° ±. X = green, Z = yellow | 155 |
| 1.786 | 1.804 | 1.758 | *Roepperite* | Sil. | 010 ⊥ X | 2V = 77°. Gel. HCl | 194 |
| 1.786 | 1.797 | 1.759 | Tephroite | Sil. | 010 ⊥ X | 2V = 65°. Gel. HCl | 194 |
| 1.788 | 1.818 | 1.783 | *Lossenite* | Sul. + | X = *b*; Z = *c* | 2V = 50°. Red ±. Sol. HCl | 120 |
| 1.788 | 1.800 | 1.777 | *Retzianite* | Arsen. | Y = *b*; Z = *a* | 2V = Lg. Brown: X < Z | 154 |
| 1.788 | 1.837 | 1.787 | Monazite | Phos. | 001 ⊥ Z ± | 2V = Sm. Yellow: X < Y | 138 |
| 1.79 | 2.05 | 1.78 | *Ferrimolybdite* | Molyb. | 001 ⊥ Z | 2V = 28°. Yellow: X < Z | 108 |
| 1.79 | 1.85 | 1.75 | *Uraconite* | Sul. | X = *a*; Z = *c* | 2V = Mod. Yellow ± | 110 |
| 1.79 ± | 1.807 | 1.73 | *Pseudomalachite* | Phos. | Z ∥ fib. | 2V = 50°. Green | 135 |
| 1.79 | .015 ± | | *Ardennite* | Sil. | 010 ⊥ Y | 2V = Var. Yellow: X > Z | 440 |
| 1.792 ± | 1.803 | 1.768 | Hortonolite | Sil. | 010 ⊥ X | 2V = 70°. Gel. HCl | 192 |
| 1.793 | 1.812 | 1.784 | Scorodite | Arsen. | X = *b*; Y = *a* | 2V = 70°. Green, pleo. | 139 |
| 1.793 | 1.809 | 1.756 | *Thortveitite* | Sil. | 110; Y = *b* | 2V = 66°. X = gr., Z = yel. | 211 |
| 1.793 | 1.802 | 1.780 | *Sarkinite* | Arsen. | 100; Y = *b* | 2V = 83°. Pink; yellow | 135 |
| 1.794 | 1.803 | 1.794 | *Arseniopleite* | Arsen. | 10$\bar{1}$1. Z = *c* | Also biax. Red | 153 |
| 1.795 | 1.815 | 1.780 | *Barthite* | Arsen. | None | 2V = 90° ±. Green; pleo. | 160 |
| 1.80 ± | 1.81 ± | 1.78 ± | Tephroite | Sil. | 010 ⊥ X | 2V = Lg. Gel. HCl | 194 |
| 1.80 ± | .006 | | Enigmatite | Sil. | 110 at 66° | Z ∧ *c* = +45° ±. 2V = 32. Brown: X < Z | 428 |

## TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ or $N_g - N_p$ | $N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.77 | 1.782 | 1.745 | **Acmite** | Sil. | 110 at 87° | $X \wedge c = 5°\pm$. $2V = 69°\pm$. Br. or gr: $X<Z$ | 234 |
| 1.785 | | 1.829 | 1.747 | *Olivenite* | Arsen. | $X=a$; $Y=c$ | $2V=$Lg. Green | 132 |
| | 1.785 | 1.785 | 1.57 | *Pistomesite* | Carb. | $10\bar{1}1$. $X=c$ | Efferv. HCl. G.=3.4 | 75 |
| 1.788 | | 1.837 | 1.787 | Monazite | Phos. | 001⊥Z± | $2V=$Sm. Yellow: $X<Y$ | 138 |
| 1.79 | | .015± | | *Ardennite* | Sil. | 010⊥Y | $2V=$Var. Yellow: $X>Z$ | 440 |
| 1.8± | | .01 | | *Thorite* | Ox. | 110 at 90° | $Z=c$. G.=5.3. Yellow | 185 |
| | 1.80± | Strong | | *Cronstedtite* | Sil. | 001⊥X± | $2V=0°\pm$. X=brown, Z=green | 285 |
| | 1.80 | 1.80 | 1.72 | *Ferritungstite* | Tung. | Z ‖ fib. | Hex. Yellow± | 107 |
| | 1.8± | 1.8± | 1.765 | *Cornetite* | Phos. | $X=a$; $Y=c$ | $2V=30°\pm$. Blue | 132 |
| | 1.80 | 1.80 | 1.585 | Rhodochrosite | Carb. | $10\bar{1}1$. $X=c$ | G.=3.7±. Efferv. HCl | 77 |
| 1.801 | | 1.849 | 1.800 | Monazite | Phos. | 001⊥Z± | $2V=$Sm. Yellow: $X<Y$ | 138 |
| 1.801 | | 1.834 | 1.783 | *Flinkite* | Arsen. | $Y=c$; $Z=a$ | $2V=$Lg. X=green, Z=brown | 154 |
| 1.807 | | 1.84 | 1.79 | *Leucochalcite* | Arsen. | $Z=c$? | $2V=$Lg. Rare | 136 |
| 1.809 | | 1.830 | 1.806 | *Warwickite* | Bor. | 100⊥Z | $2V=59°$. Brown: $X>Z$ | 95 |
| | 1.81 | 1.863 | 1.772 | *Olivenite* | Arsen. | $X=a$; $Y=c$ | $2V=82°$. Green | 132 |
| 1.81± | | .030 | | *Törnebohmite* | Sil. | ? | $2V=30°$. Olive; pleo. | 414 |
| | 1.81 | 1.830 | 1.788 | *Hancockite* | Sil. | 001 | $2V=50°\pm$. X=pink, Y=brown | 316 |
| | 1.81 | 1.81 | 1.74 | *Carphosiderite* | Sul. | 0001⊥X | G.=2.6±. Yellow± | 107 |
| | 1.81 | 1.82 | 1.78 | *Knebelite* | Sil. | 010⊥X | $2V=55°\pm$. Gel. HCl | 193 |
| 1.815± | | 1.85± | 1.81± | *Cornwallite* | Arsen. | Y ‖ fib. | $2V=$Sm. Green | 136 |
| | 1.815 | 1.825 | 1.775 | *Pascoite* | Van. | 010⊥X | $2V=50°$. X=yellow, Z=orange | 160 |
| | 1.815 | 1.815 | 1.761 | *Molybdophyllite* | Sil. | 0001⊥X | G.=4.72. Rare | 407 |
| | 1.817 | 1.820 | 1.715 | *Jarosite* | Sul. | 0001⊥X | Also biax. Yellow | 114 |
| 1.818 | | 1.821 | 1.817 | *Cerite* | Sil. | None | $2V=25°$. Reddish± | 422 |
| | 1.82 | 1.84 | 1.78 | **Acmite** | Sil. | 110 at 87° | $X \wedge c = +5°\pm$. $2V=60°$. Gr. or br. $X>Z$ | 234 |
| | 1.82 | 1.82 | 1.595 | *Pistomesite* | Carb. | $10\bar{1}1$. $X=c$ | G.=3.4±. Efferv. HCl | 75 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.82 | 1.82 | 1.715 | *Jarosite* | Sul. | 0001⊥X | G.=3.2. Yellow | 114 |
| 1.82 | 1.82 | 1.73 | *Carphosiderite* | Sul. | 0001⊥X | G.=2.6±. Yellow | 107 |
| 1.82 | 1.82 | 1.595 | *Sideroplesite* | Carb. | 10$\bar{1}$1. X=$c$ | G.=3.7±. Efferv. HCl | 75 |
| 1.827 | 1.864 | 1.792 | Iddingsite | Sil. | 100⊥X | 2V=80°. Brown: X<Z | 437 |
| 1.83 | 1.83 | 1.63 | Rhodochrosite | Carb. | 10$\bar{1}$1. X=$c$ | G.=3.7±. Efferv. HCl | 77 |
| 1.83± | Strong | | *Carminite* | Arsen. | 110. Z=$c$? | G.=4.1. Red | 154 |
| 1.83 | 1.83 | 1.61 | *Oligonite* | Carb. | 10$\bar{1}$1. X=$c$ | G.=3.8±. Efferv. HCl | 76 |
| 1.83 | 1.83 | 1.79 | *Beaverite* | Sul. | X=$c$ | G.=4.36. Yellow | 115 |
| 1.831 | 1.846 | 1.800 | *Higginsite* | Arsen. | X=$a$; Z=$c$ | 2V=90°±. Green; pleo. | 132 |
| 1.832 | 1.832 | 1.750 | *Natrojarosite* | Sul. | 0001⊥X | G.=3.18. Yellow: X<Z | 114 |
| 1.838 | 1.859 | 1.809 | *Linarite* | Sul. | 100, 001 | 2V=80°. Blue: X<Z | 104 |
| 1.84 | 1.85 | 1.81 | *Knebelite* | Sil. | 010⊥X | 2V=55°±. Gel. HCl | 193 |
| 1.840 | 1.888 | 1.792 | *Lautarite* | Iod. | 011; Y=$b$ | 2V=90°±. Sol. HCl | 89 |
| 1.840 | 1.885 | 1.830 | *Dufrenite* | Phos. | 010⊥Z | 2V=90°±. X=brown, Z=green | 142 |
| 1.84 | 1.85 | 1.69 | *Tagilite* | Phos. | 010; X=$c$± | 2V=Sm. Green | 137 |
| 1.840 | 1.845 | 1.773 | *Chalcosiderite* | Phos. | 010⊥X± | 2V=24°. Green: X<Z | 157 |
| 1.84 | .03 | | *Heterosite* | Phos. | 001⊥X | 2V=Lg. X=brown, Z=violet | 141 |
| 1.842 | 1.857 | 1.825 | *Dietzeite* | Chrom. | 100⊥X± | 2V=86°. Yellow | 121 |
| 1.849 | 1.849 | 1.621 | *Smithsonite* | Carb. | 10$\bar{1}$1. X=$c$ | G.=4.3. Efferv. HCl | 78 |
| 1.845 | 1.890 | 1.840 | *Kraurite* | Phos. | 010⊥Z | 2V=28°. X=yellow, Z=brown or gr. | 142 |
| 1.846 | 1.864 | 1.792 | Iddingsite | Sil. | 100⊥X | 2V=75°±. Brown: X<Z | 437 |
| 1.848 | 1.848 | 1.817 | *Högbomite* | Ox. | X=$c$ | G.=3.8. Brown: X<Z | 65 |
| 1.85 | 1.98 | 1.84 | *Ludwigite* | Bor. | Z ‖ fib. | 2V=Sm. X=green, Z=brown | 94 |
| 1.85± | 1.86 | 1.85 | **Zircon** (alt.) | Ox. | Poor | Tet. G.=4.2. Gray | 183 |
| 1.85 | 1.86 | 1.82 | **Fayalite** | Sil. | 010⊥X | 2V=50°±. Gel. HCl | 192 |
| 1.853 | 1.853 | 1.803 | *Högbomite* | Ox. | X=$c$ | G.=3.8. Brown: X<Z | 65 |
| 1.855 | 1.855 | 1.600 | *Spherocobaltite* | Carb. | 10$\bar{1}$1. X=$c$ | G.=4.1. Efferv. HCl | 78 |
| 1.86 | 1.86 | 1.62 | *Sideroplesite* | Carb. | 10$\bar{1}$1. X=$c$ | G.=3.7±. Efferv. HCl | 75 |
| 1.86 | 1.86 | 1.62 | *Oligonite* | Carb. | 10$\bar{1}$1. X=$c$ | G.=3.8±. Efferv. HCl | 76 |
| 1.86 | 1.88 | 1.82 | *Erinite* | Arsen. | One⊥Z | 2V=Mod. Green | 133 |
| 1.861 | 1.880 | 1.831 | *Atacamite* | Cu, OH, Cl | 010⊥X | 2V=75°. Green: X<Z | 38 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ or $N_g-N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.79 | | .015± | | *Ardennite* | Sil. | 010⊥Y | 2V=Var. Yellow: X>Z | 440 |
| | 1.83 | 1.83 | 1.79 | *Beaverite* | Sul. | X=*c* | G.=4.36. Yellow | 115 |
| | 1.84 | .03 | | *Heterosite* | Phos. | 001⊥X | 2V=Lg. X=brown, Z=violet | 141 |
| | 1.85 | 1.86 | 1.82 | **Fayalite** | Sil. | 010⊥X | 2V=50°. Gel. HCl | 192 |
| 1.86 | | 1.92± | 1.85± | *Purpurite* | Phos. | 001⊥X | 2V=38°. X=gray, Z=red | 141 |
| | 1.86 | 1.86 | 1.62 | **Siderite** | Carb. | 10$\bar{1}$1. X=*c* | G.=3.85. Efferv. HCl | 76 |
| | 1.866 | 1.909 | 1.818 | *Caledonite* | Sul. | 001⊥Z | 2V=85°. Green: Y<Z | 120 |
| | 1.87 | 1.87 | 1.83± | *Beaverite* | Sul. | X=*c* | G.=4.36. Yellow± | 115 |
| | 1.87 | 1.88 | 1.750 | Becquerelite * | Ox. | 001⊥X | 2V=Sm. Yellow: X<Z | 60 |
| 1.87 | | 1.90 | 1.86 | *Synadelphite* | Arsen. | X∧*c*=45° | 2V=Sm. Brown | 155 |
| | 1.870 | 1.870 | 1.792 | *Arseniosiderite* | Arsen. | 001⊥X | Also biax. X=yellow, Z=brown | 153 |
| | 1.87 | 1.91 | 1.73 | *Clinoclasite* | Arsen. | 001⊥X± | 2V=53°. Green; pleo. | 135 |
| | 1.870 | 1.895 | 1.670 | *Tyuyamunite* | Van. | 001⊥X | 2V=45°±. Yellow: X<Z | 147 |
| | 1.875 | 1.875 | 1.633 | **Siderite** | Carb. | 10$\bar{1}$1. X=c | G.=3.89. Efferv. HCl | 76 |
| | 1.875 | 1.909 | 1.655 | Malachite | Carb. | 001⊥X± | 2V=43°. Green: X<Z | 83 |
| | 1.875± | 1.875 | 1.785 | *Plumbojarosite* | Sul. | 10$\bar{1}$1. X=*c* | Also biax. X=yellow, Z=red | 115 |
| 1.879 | | 2.057 | 1.817 | *Uvanite* | Van. | Two pinac. | 2V=52°. Y=brown, Z=yellow | 148 |
| | 1.88 | 1.89 | 1.84 | **Fayalite** | Sil. | 010⊥X | 2V=47°. Gel. HCl | 192 |
| 1.88 | | 1.93 | 1.87 | *Hemafibrite* | Arsen. | 010⊥X | 2V=35°. Red-brown | 135 |
| | 1.88 | Mod. | | *Chenevixite* | Arsen. | ? | Green, yellow | 156 |
| | 1.88 | .01 | | *Chevkinite* | Sil. | Z=*b* | 2V=Mod. Brown: X<Z | 423 |
| 1.883 | | 1.895 | 1.878 | Anglesite | Sul. | 001⊥X | 2V=70°±. G.=6.3 | 99 |
| | 1.89± | 1.91 | 1 86 | *Heterosite* | Phos. | 001⊥X | 2V=Lg. X=brown, Z=red | 136 |
| | 1.89 | Strong | | Ilvaite | Sil. | 001⊥Z | 2V=Sm. X=brown, Z=green | 141 |
| 1.894 | | 1.996 | 1.888 | **Titanite** | Sil. | 110 at 66° | Y=*b*. 2V=Sm. $\rho>v$, strong | 204 |
| | 1.895 | 1.92 | ? | *Carnotite* | Van. | 001⊥X | 2V=40°±. Yellow± | 148 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.898 | 1.898 | 1.815 | *Mazapilite* | Arsen. | X=*c* | 2V=0°±. Brown: X<Z | 156 |
| 1.90 | 2.12 | 1.90 | *Trippkeite* | Arsen. | 100. Z=*c* | Tet. Blue-green | 159 |
| 1.9± | ? | ? | *Katoptrite* | Sil. | 100⊥Z±? | 2V=25°. Red-brown | 441 |
| 1.910 | 1.945 | 1.910 | *Ganomalite* | Sil. | 0001⊥Z | G.=5.6. Gel. HCl | 407 |
| 1.910 | 1.977 | 1.89± | *Schultenite* | Phos. | 010⊥X | Z∧*c*=+66°. G.=5.94 | 123 |
| 1.91 | .01 | | *Daubréeite* | Bi, OH, Cl | ? | G.=6.4. Sol. HCl | 39 |
| 1.91 | Strong | | *Cervantite* | Ox. | Z ∥ fib. | G.=4 | 67 |
| 1.915 | Weak | | *Huegelite* | Van. | 010? | 2V=Sm. Yellow: X<Y | 127 |
| 1.917 | 1.927 | 1.917 | *Nasonite* | Sil. | 0001⊥Z | G.=5.4. Gel. HCl | 407 |
| 1.918 | 1.934 | 1.918 | Scheelite | Tung. | 111 | G.=6.1. Dec. HCl | 97 |
| 1.92 | Strong | | Ilvaite | Sil. | 001⊥Z | 2V=Sm. X=brown, Z=green | 431 |
| 1.92 | 1.92+ | 1.85 | *Purpurite* | Phos. | 001⊥X | 2V=38°. X=gray, Z=red | 141 |
| 1.92 | 2.01 | 1.87 | *Claudétite* | Ox. | 010⊥Y | 2V=58°. Z∧*c*=6° | 45 |
| 1.920 | 1.956 | 1.885 | *Tsumebite* | Phos. | 001? | 2V=89°. Green: X<Z | 137 |
| 1.92 | ? | ? | *Calciovolborthite* | Van. | One | Extr. disp. | 135 |
| 1.923 | 1.968 | 1.923 | **Zircon** | Ox. | Z=*c* | G.=4.7. White, gray, brown | 183 |
| 1.93± | 1.96 | 1.85 | *Chapmanite* | Sil. | Z ∥ laths | G.=3.58. Olive green± | 440 |
| 1.93 | Weak | | *Corkite* | Sul. | 0001⊥X | Also biax. Abn. int. colors | 119 |
| 1.952 | 1.968 | 1.80 | *Tyuyamunite* | Van. | 001⊥X | 2V=45°±. Yellow: X<Z | 147 |
| 1.935 | 2.05 | 1.92 | **Titanite** | Sil. | 110 at 66° | Y=*b*. 2V=Sm., ρ>*v*, strong | 204 |
| 1.935 | 2.03 | 1.92 | *Keilhauite* | Sil. | 110 at 66° | Y=*b*. 2V=50°±, ρ>*v*, strong. Br., pleo. | 205 |
| 1.94 | 1.95 | 1.71 | *Durdenite* | Tel. | 001⊥X | 2V=Sm. Yellow: X<Z | 118 |
| 1.945 | 1.971 | 1.945 | *Nasonite* | Sil. | 0001⊥Z | G.=5.4. Gel. HCl | 407 |
| 1.95 | 1.96 | 1.92 | *Manganostibite* | Antim. | 010⊥X | 2V=Sm. X=brown, Z=dark | 155 |
| 1.955 | 1.965 | 1.702 | *Durdenite* | Tel. | 001⊥X | 2V=23°. Yellow: X<Z | 118 |
| 1.960 | 2.015 | 1.960 | **Zircon** | Ox. | Z=*c* | G.=4.7. White, gray, brown | 183 |
| 1.96 | ? | 1.96 | *Dixenite* | Arsen.+ | 0001⊥Z | G.=4.2. Yellow | 161 |
| 1.96 | Mod. | | *Beudantite* | Sul.+ | 0001⊥X | Also biax. Abn. disp. | 119 |
| 1.961 | 1.968 | 1.947 | *Alamosite* | Sil. | 010⊥Y | 2V=65°. Gel. $HNO_3$ | 401 |

* Indices as given by V. Billiet: *Bull. Soc. Fr. Min.*, XLIX, 1926, p. 136.

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | | − | $N_g$ or $N_g-N_p$ | $N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|---|
| 1.79 | | | .015+ | | *Ardennite* | Sil. | 010⊥Y | 2V=Var. Yellow: X>Z | 440 |
| | | 1.895 | 1.92 | ? | *Carnotite* | Van. | 001⊥X | 2V=40°±. Yellow | 148 |
| | 1.91 | | Strong | | *Cervantite* | Ox. | Z ‖ fib. | G.=4 | 67 |
| 1.963 | | | 1.966 | 1.963 | *Hyalotekite* | Sil. | Two at 90° | 2V=Sm. G.=3.8 | 422 |
| 1.967 | | | 1.978 | 1.967 | *Powellite* | Molyb. | 111. Z=*c* | Tet. G.=4.4 | 98 |
| 1.97 | | | 1.99 | 1.95 | *Bayldonite* | Arsen. | Z∧*c*=45° | 2V=Lg. Green | 137 |
| 1.973 | | | 2.656 | 1.973 | *Calomel* | Hal. | 100 | G.=6.48. Extr. biref. | 30 |
| | | 1.975 | 2.005 | 1.871 | *Walpurgite* | Arsen. | 010? | 2V=52°. Yellow± | 148 |
| | | 1.98 | 1.98 | ? | *Diaboléite* | Hal. | 001⊥X | G.=6.4. Blue: X<Z | 37 |
| 1.985 | | | 2.05 | 1.955 | *Uranospherite* | Uran. | 100⊥X | 2V=Lg. Yellow± | 109 |
| | | 1.99 | 2.01 | 1.93 | *Lanarkite* | Sul. | 001⊥X± | 2V=47°. G.=6.6± | 102 |
| | 1.99 | | Weak | | *Parsonsite* | Phos. | Z∧*c*=12° | G.=6.23. Brown± | 148 |
| 1.99 | | | Weak | | *Agricolite* | Sil. | Fibers | 2V=Lg. Yellow± | 414 |
| 1.997 | | | 2.093 | 1.997 | Cassiterite | $SnO_2$ | 110 at 90° | Z=*c*. Tet. Brown±, etc. | 52 |
| 2.0 | | | .02± | | *Ardennite* | Sil.+ | 010, 110 | 2V=Var. Yellow: X>Z | 440 |
| | 2± | | Strong | | *Pseudocotunnite* | Hal. | Z=*c* | Sol. $H_2O$. Yellow± | 33 |
| | | 2± | Mod. | | Graphite | C | 0001⊥X | G.=2.25. Opaque | 14 |
| | | 2.00 | 2.00 | 1.82 | *Bismite* | Ox. | 0001⊥X | G.=4.36. Sol. $HNO_3$ | 43 |
| | | 2.00 | 2.01 | 1.87 | *Leadhillite* | Sul. | 001⊥X± | 2V=10°. Ps. Hex. twin. | 120 |
| 2.008 | | | 2.029 | 2.008 | Zincite | ZnO | 0001⊥Z | G.=5.5±. Red | 41 |
| | | 2.01 | 2.03 | 1.9± | *Walpurgite* | Arsen. | 010? | 2V=52°. Yellow± | 148 |
| | | 2.01 | 2.02 | 2.00 | *Volborthite* | Van. | One⊥Bx. | 2V=Var. Green± | 137 |
| 2.03 | | | Weak | | *Agricolite* | Sil. | Fibers | 2V=Lg. Yellow | 414 |
| 2.03 | | | Mod. | | *Voltzite* | $Zn_5OS_4$ | Z=*c* | G.=3.7. Yellow±, etc. | 28 |
| | | 2.03 | 2.03 | 2.00 | *Pseudoboléite* | Hal. | 001⊥X | G.=4.85. Blue | 37 |
| 2.038 | | | 2.245 | 1.958 | Sulfur | S | X=*a*; Z=*c* | 2V=69°. Yellow± | 14 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.04 | .02± | | *Boléite* | Hal. | 001 ⊥ X | G. = 4.9±. Blue | 37 |
| 2.041 | 2.041 | 1.926 | *Cumengéite* | Hal. | 101. X = $c$ | G. ± 4.8. Blue | 37 |
| 2.05 | 2.10 | 2.01 | *Calciovolborthite* | Van. | ? | 2V = 83°. Green±. Extr. disp. | 135 |
| 2.05 | Strong | | *Fernandinite* | Van. | Fibers | Green; not pleo. | 148 |
| 2.05 | 2.065 | 1.908 | *Pinakiolite* | Bor. | 010 ⊥ X | 2V = 32°. Brown: X > Z | 94 |
| 2.06 | Weak | | *Cervantite* | Ox. | Fibers | Data vary. G. = 4 | 67 |
| 2.061 | 2.061 | 2.049 | Pyromorphite | Phos. | X = $c$ | 2V = 0°±. Colorless or X = yel., Z = gr. | 131 |
| 2.07 | 2.08 | 2.06 | *Carnotite* | Phos. | 001 ⊥ X | 2V = 50°±. Yellow± | 148 |
| 2.07 | 2.07 | 2.05 | *Barysilite* | Sil. | 0001 ⊥ X | G. = 6.7. Gel. $HNO_3$ | 401 |
| 2.074 | 2.076 | 1.803 | Cerussite | Carb. | 110 at 63° | X = $c$. 2V = 9°. G. = 6.57. Efferv. HCl | 80 |
| 2.08 | 2.08 | 1.82 | *Bindheimite* | Antim. | Prism. | 2V = 0°. G. = 4.8± | 160 |
| 2.09 | 2.09 | 2.07± | *Boléite* | Hal. | 001 ⊥ X | G. = 4.9±. Blue | 37 |
| 2.09 | 2.10 | 1.95 | *Emmonsite* | Tel. | 010 ⊥ Y | 2V = 20°. Sol. HCl | 118 |
| 2.09 | 2.09 | 1.94 | *Hydrocerussite* | Carb. | 0001 ⊥ X | G. = 6.8. Efferv. HCl | 82 |
| 2.09 | .01± | | *Montanite* | Tel. | One? ⊥ X | 2V = Sm. Abn. int. colors | 109 |
| 2.1± | Dist. | | *Georgiadesite* | Arsen. | X = $b$; Z = $c$ | 2V = Lg. G. = 7.1 | 133 |
| 2.1± | 2.16 | 2.08 | *Trigonite* | Arsen. | 010 ⊥ Y | Ext. in 010 at 45° | 159 |
| 2.10 | 2.23 | 1.70 | *Metahewettite* | Van. | Z ‖ elong. | 2V = 52°. X = yellow, Z = red | 160 |
| 2.10 | 2.11 | 2.05 | **Goethite** | Ox. | 010 ⊥ X | 2V = Sm. Yellow: $a > b$ | 47 |
| 2.102 | 2.126? | 1.816 | *Fiedlerite* | Hal. | 100 ⊥ X± | Z = $b$. G. = 5.88 | 39 |
| 2.116 | 2.158 | 2.077 | *Laurionite* | Hal. | 100 ⊥ X | 2V = 82°. G. = 6.24 | 38 |
| 2.118 | 2.145 | 2.118 | *Phosgenite* | Carb. | 110, 100 | G. = 6.1±. Sol. $HNO_3$ | 85 |
| 2.13 | 2.21 | 2.13 | *Penfieldite* | Hal. | 0001 ⊥ Z | Sol. $HNO_3$ | 38 |
| 2.13 | 2.13 | 1.94 | *Bismutospherite* | Carb. | One? ⊥ X | G. = 7.3. Efferv. HCl | 86 |
| 2.135 | 2.135 | 2.120 | *Mimetite* | Arsen. | X = $c$ | Also biax. Yellow: X < Z | 132 |
| 2.146 | Strong | | *Paralaurionite* | Hal. | 001; Y = $b$ | Violet±: Y > Z | 39 |
| 2.15 | 2.15 | 2.135 | *Mimetite* | Arsen. | X = $c$ | Also biax. Colorless or yellow: X < Z | 132 |
| 2.15 | 2.18 | 2.14 | *Atelestite* | Arsen. | 001 | 2V = 44°. Yellow± | 143 |
| 2.15 | Strong | | *Cuprotungstite* | Tung. | One | Green. Dec. HCl | 105 |
| 2.15 | 2.15 | 2.04 | *Matlockite* | Hal. | 001 ⊥ X | Also biax. G. = 7.2 | 37 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g-N_p$) | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 2.10 | 2.11 | 2.05 | **Goethite** | Ox. | 010⊥X | 2V=Sm. Yellow: $a>b$ | 47 |
| | 2.15 | .05± | | *Bismutite* | Carb. | Z ∥ fib. | 2V=Mod. Efferv. HCl | 86 |
| | 2.16 | 2.16 | 2.14 | *Bellite* | Arsen.+ | X ∥ fib. | Yellow: X<Z | 119 |
| 2.17 | | 2.31 | 2.12 | *Melanotekite* | Sil. | Two | 2V=67°. Brown: X<Z | 427 |
| | 2.18 Li | 2.35 | 2.00 | *Tellurite* | Ox. | 010⊥X | 2V=90°±. G.=5.9 | 59 |
| | 2.18 | 2.35 | 1.77 | *Hewettite* | Van. | Z ∥ elong. | 2V=Mod. Red: X<Z | 160 |
| | 2.18 | 2.18 | 2.16 | *Kleinite* | Hal. | Tr.? | 2V=Sm. Sol. HCl | 38 |
| 2.18 | | .01± | | *Iodyrite* | Hal. | 0001⊥Z | Abn. int. colors | 30 |
| 2.19 | | 2.21 | 2.19 | *Kleinite* | Hal. | 0001⊥Z | G.=7.98. Sol. HCl | 38 |
| | 2.19 | 2.20 | 2.13 | *Baddeleyite* | Ox. | 001⊥X± | 2V=30°. Brown: X>Z | 60 |
| 2.20 | | 2.31 | 2.10 | *Kentrolite* | Sil. | 110 at 65° | X=$a$. 2V=88°. Brown: X<Z | 427 |
| 2.20 | | 2.51 | 1.94 | *Lepidocrocite* | Ox. | 010⊥X | 2V=83°; Red: X<Z | 48 |
| 2.20 | | 2.33 | 2.19 | *Tripuhyite* | Antim. | ? | 2V=Sm. Yellow | 160 |
| 2.21 | | 2.22 | 2.21 | *Iodyrite* | Hal. | 0001⊥Z | Abn. int. colors | 30 |
| 2.217 | | 2.260 | 2.199 | *Cotunnite* | Hal. | 001⊥Z | 2V=67°. G.=5.84 | 32 |
| 2.22 | | 2.32 | 2.17 | Huebnerite | Tung. | 010⊥X | 2V=73°. Green or brown: X<Z | 101 |
| | 2.22 | 2.22 | 2.11 | *Vauquelinite* | Chrom. | X ∥ fib.± | 2V=Sm. Colorless or X=gr., Z=br. | 121 |
| | 2.24 | 2.26 | 2.09 | *Tungstite* | Ox. | 001⊥X | 2V=Sm. Yellow | 60 |
| 2.25 Li | | 2.53 | 2.25 | *Manganite* | Ox. | 010⊥Y | 2V=Sm. Brown: X<Z | 48 |
| | 2.25 | 2.25 | 2.20 | *Endlichite* | Arsen. | X=$c$ | Yellow± | 132 |
| 2.25± | | 2.34 | 2.19 | *Mangantantalite* | Tan. | 100 | 2V=Lg. Red: X<Z | 165 |
| | 2.26 | .13± | | *Cuprodescloizite* | Van. | X ∥ fib. | 2V=60°. Brown: X<Z | 133 |
| | 2.26 | 2.26 | 2.10 | *Heterolite* | Ox. | 001⊥X | G.=4.8. Brown: X>Z | 65 |
| | 2.265 | 2.35 | 2.185 | *Descloizite* | Van. | X=$c$; Z=$a$ | 2V=Lg. Yellow: X<Z | 133 |
| | 2.269 | 2.269 | 2.182 | *Stolzite* | Tung. | 001⊥X | G.=8±. Dec. $HNO_3$ | 98 |
| 2.27 Li | | 2.42 | 2.27 | *Tapiolite* | Tant. | Z=$c$ | G.=7.5±. Brown: X<Z | 164 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.27 | 2.30 | 2.27 | *Raspite* | Tung. | 100; Y=*b* | 2V=Sm. Yellow: X<Z | 101 |
| 2.27 | 2.31 | 2.24 | *Mendipite* | Hal. | 110; 010 | X=*a*. 2V=90°±. Z ∥ elong. | 38 |
| 2.28 | .05± | | *Bismutite* | Carb. | Z ∥ fib. | 2V=Mod. Efferv. HCl | 86 |
| 2.295 | 2.295 | 2.285 | *Finnemanite* | Arsen. | $10\bar{1}1$ | G.=7.26. Olive | 159 |
| 2.30 Li | 2.40 | 2.30 | *Hjelmite* | Tant. | ? | 2V=Sm. Brown: X<Z | 166 |
| 2.3 Li | 2.3 | ? | *Plattnerite* | Ox. | X=*c* | G.=8.5. Brown | 53 |
| 2.31 | 2.33 | 2.21 | *Cuprodescloizite* | Van. | X ∥ fib. | 2V=60°. Brown: X<Z | 133 |
| 2.31 | 2.31 | 1.95 | *Geikielite* | Ox. | $10\bar{1}1$. X=*c* | G.=3.9. Purple | 67 |
| 2.32± Li | 2.42 | 2.26 | Wolframite | Tung. | 010⊥X | Often opaque | 101 |
| 2.32± | 2.43 | 2.26 | *Tantalite* | Tant. | 100 | 2V=Lg. Red: X<Z | 165 |
| 2.32 Li | 2.32 | 2.25 | *Ecdemite* | Arsen. | 001⊥X | Also biax. Yellow± | 159 |
| 2.34 | 2.34 | 2.14 | *Heterolite* | Ox. | 001⊥X | G.=4.85. Brown: X>Z | 65 |
| 2.35 | 2.35 | 2.31 | *Endlichite* | Van. | X=*c* | Also biax. Yellow± | 132 |
| 2.35 Li | 2.40 | 2.30 | *Nadorite* | Antim. | 100⊥X | 2V=Lg. Yellow± | 159 |
| 2.35 Li | 2.36 | 2.25 | *Schwartzembergite* | Hal. | 001⊥X | 2V=Sm. Yellow± | 38 |
| 2.35 | 2.35 | 2.18 | *Valentinite* | Ox. | 010⊥Z | 2V=Sm. Sol. HCl | 45 |
| 2.35 | 2.35 | 2.33 | *Lorettoite* | Hal. | 001⊥X | G.=7.5. Yellow± | 38 |
| 2.354 | 2.354 | 2.299 | Vanadinite | Van. | X=*c* | Yellow±: X<Z | 131 |
| 2.356 | 2 378 | 2.356 | *Wurtzite* | ZnS | X ∥ fib. | G.=4.0. Yellow: X>Z | 20 |
| 2.36 Li | 2.48 | 2.28 | *Brackebuschite* | Van. | ? | 2V=Lg. Brown: X<Z | 125 |
| 2.36 Li | 2.36 | 2.31 | *Langbanite* | Ox.? | X=*c* | G.=4.7. Brown: X<Z | 66 |
| 2.36± Li | 2.375 | 2.35 | *Pseudobrookite* | Ox. | 001⊥X | 2V=50°. Brown: Y>Z | 165 |
| 2.37 Li | 2.66 | 2.31 | *Crocoite* | Chrom. | 110 at 86° | Y=*b*. Z∧*c*=−6°. 2V=57°. Orange± | 101 |
| 2.38 Li | 2.65 | 2.34 | *Phenicochroite* | Chrom. | One | 2V=Mod. Red | 100 |
| 2.39 Li | 2.42 | 2.38 | *Pseudobrookite* | Ox. | 001⊥X | 2V=50°. Brown: Y>Z | 165 |
| 2.394 | 2.400 | 2.260 | **Goethite** | Ox. | 010⊥X | 2V=Sm. Yellow: *a*>*b* | 47 |
| 2.40 | 2.40 | 2.37 | *Lorettoite* | Hal. | 001⊥X | G.=7.5. Yellow± | 38 |
| 2.40± Li. | Extr. | | Columbite | Colum. | 100 | 2V=Lg. Opaque± | 165 |
| 2.40 Li | Weak | | *Minium* | Ox. | X ∥ elong. | Red: X>Z. Abn. int. colors | 65 |
| 2.40 Li | Strong | | *Ferberite* | Tung. | 010⊥X | Nearly opaque | 101 |

TABLE IVB.—REFRINGENCE OF ANISTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ (or $N_g-N_p$) | $N_p$ | Mineral | Chem. | Cleavage. Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 2.356 | | 2.378 | 2.356 | *Wurtzite* | ZnS | X ‖ fib. | G.=4.0. Yellow: X>Z | 20 |
| | 2.402 Li | 2.402 | 2.304 | Wulfenite | Molyb. | 111; X=*c* | Also biax. G.=6.9 | 98 |
| 2.404 | | 2.457 | 2.374 | *Stibiotantalite* | Tant. | 100⊥X | 2V=75°. Yellow± | 167 |
| 2.419 | | 2.459 | 2.398 | *Stibiocolumbite* | Colum. | 100⊥X | 2V=73°. Yellow± | 167 |
| 2.45 Li | | 2.51 | 2.45 | *Derbylite* | Titan. | ? | 2V=0°±. G.=4.5. Brown | 162 |
| | 2.45± Li | Strong | | *Mangancolumbite* | Colum. | 100 | 2V=Lg. Opaque± | 165 |
| 2.46 | | 2.48 | 2.46 | *Wurtzite* | ZnS | X ‖ fib. | G.=4.0. Yellow: X>Z | 20 |
| | 2.46 Li | 2.46 | 2.15 | *Hausmannite* | Ox. | 001⊥X | G.=4.8. Dark brown | 64 |
| | 2.481 | 2.481 | 2.210 | *Pyrophanite* | Ox. | 02$\bar{2}$1. X=*c* | G.=4.5. Red | 67 |
| 2.50 Li | | 2.65 | 2.37 | *Montroydite* | Ox. | 010⊥Z | 2V=Lg. Yellow± | 41 |
| 2.50 Li | | Mod. | | *Strueverite* | Tit. | ? | G.=5.56. O=brown, E=green | 164 |
| | 2.50 Li | Mod. | | *Senaite* | Ox. | ? | G.=5±. Opaque± | 67 |
| | 2.50 Li | 2.51 | 2.41 | *Pucherite* | Van. | 001⊥X | 2V=19°. Brown± | 138 |
| | 2.5 | 2.5 | 2.3 | *Hydrohematite* | Ox. | X ‖ fib. | G.=4.5–5. Red± | 45 |
| 2.506 | | 2.529 | 2.506 | *Greenockite* | CdS | 10$\bar{1}$0 | G.=4.8. Yellow± | 21 |
| | 2.534 | 2.534 | 2.489 | *Octahedrite* | $TiO_2$ | 001⊥X | Yellow or blue: X<Z | 53 |
| 2.55 Li | | Strong | | *Koechlinite* | Molyb. | 100⊥Z | 2V=Lg. Yellow± | 107 |
| | 2.564 | 2.564 | 2.497 | *Octahedrite* | $TiO_2$ | 001⊥X | Yellow or blue: X<Z | 53 |
| 2.582 | | Weak | | *Greenockite* | CdS | 10$\bar{1}$0 | Also. biax. G.=4.8. Yellow± | 21 |
| 2.585 | | 2.705 | 2.583 | *Brookite* | $TiO_2$ | Z=*a* | 2V=30°. Brown: X<Z | 59 |
| | 2.59 Li | 2.61 | 2.46 | Realgar | AsS | 010⊥Y | 2V=40°. Red; pleo. | 22 |
| | 2.6 Li | Extreme | | *Trechmannite* | $AgAsS_2$ | 10$\bar{1}$1; 0001⊥X | Red: X<Z | 27 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.603 | 2.889 | 2.603 | **Rutile** | $TiO_2$ | 110 at 90° | Z=*c*. G.=4.2. Brown: X<Z | 50 |
| 2.61 Li | 2.71 | 2.51 | *Massicotite* | PbO | 100⊥Y | 2V=Lg. Yellow: X<Z | 41 |
| 2.616 | 2.903 | 2.616 | **Rutile** | $TiO_2$ | 110 at 90° | Z=*c*. G.=4.2. Brown: X<Z | 50 |
| 2.62 Li | Mod. | | *Arizonite* | Tit. | ? | Nearly opaque red | 68 |
| 2.64 Li | 2.64 | 2.51± | *Lithargite* | PbO | 110 at 90° | X=*c*. G.=9.1. Yellow± | 41 |
| 2.64 Li | 2.66 | 2.35 | *Terlinguaite* | $Hg_2OCl$ | $\bar{1}01$ | 2V=20°. G.=8.7 | 39 |
| 2.654 | 2.697 | 2.654 | *Moissanite* | SiC | Z=*c* | Tinted±. Str. dispersion | 17 |
| 2.665 | 2.665 | 2.535 | *Lithargite* | PbO | 110 at 90° | X=*c*. G.=9.1. Yellow± | 41 |
| 2.7 Li | 2.7 | 2.6 | *Hydrohematite* | Ox. | X ∥ fib. | G.=4.5-5. Red± | 45 |
| 2.72+ Li | Extreme | | Orpiment | $As_2S_3$ | 010⊥X | 2E=70°. Yellow±: X>Z | 25 |
| 2.72+ Li | Extreme | | *Lorandite* | $TlAsS_2$ | 100; 001⊥X± | Y=*a*±. 2E=Lg. Red; pleo. | 28 |
| 2.72+ Li | Strong | | *Miargyrite* | $AgSbS_2$ | 010 | Nearly opaque red | 27 |
| 2.72+ Li | Extreme | | *Chalcophanite* | Ox. | 0001⊥X | G.=3.9. X=red, Z=opaque | 66 |
| 2.74+ Li | Extreme | | *Kermesite* | $Sb_2S_2O$ | 100, 101 | 2V=Sm. Red: X>Z | 28 |
| 2.84 | Strong | | *Tenorite* | CuO | 111, $1\bar{1}1$, 001 | X=brown, Z=opaque± | 41 |
| 2.913 | 3.272 | 2.913 | Cinnabar | HgS | $10\bar{1}1$ | G.=8.17. Red. Extr. disp. | 21 |
| 3± | Extreme | | *Livingstonite* | $HgSb_4S_7$ | 110 at 90° | Z=*c*. Nearly opaque red | 28 |
| 3± | Strong | | *Polybasite* | Ag,Sb,S | X=*c*±. Y=*a*± | 2E=70°. Red. G.=6.1 | 27 |
| 3.084 Li | 3.084 | 2.881 | Pyrargyrite | $Ag_3SbS_3$ | $10\bar{1}1$. X=*c* | G.=5.8. Red | 27 |
| 3.087 Li | 3.087 | 2.792 | Proustite | $Ag_3AsS_3$ | $10\bar{1}1$. X=*c* | G.=5.7. Red; pleo. | 27 |
| 3.176 | 3.188 | 3.078 | *Hutchinsonite* | Tl,Pb,As,S | 100⊥Y | G.=4.6. Red; pleo. | 28 |
| 3.22 | 3.22 | 2.94 | **HEMATITE** | $Fe_2O_3$ | X=*c* | G.=5.2. Red to opaque | 44 |
| 3.27? | ? | ? | *Smithite* | $AgAsS_2$ | 100; Y=*b* | G.=4.9. Red | 27 |
| 4.046 Li | 4.303 | 3.194 | Stibnite | $Sb_2S_3$ | 010⊥Z | Red to opaque | 25 |
| 4.7± | ? | ? | Molybdenite | $MoS_2$ | 0001⊥X | G.=4.7±. Opaque | 26 |
| Extr. | Extreme | | **Ilmenite** | $FeTiO_3$ | ? | G.=4.8±. Opaque | 66 |
| Extr. | Extreme | | *Chloroxiphite* | Hal. | 001⊥X± | Y=brown; Z=green | 39 |

## SUPPLEMENTARY TABLE IV B.—REFRINGENCE OF ANISOTROPIC MINERALS

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ or $N_g$–$N_p$ | Mineral | Chem. | Cleavage, Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.301 | | 1.307 | 1.301 | *Ferrucite* | $NaBF_4$ | X = c | G. = 2.50. Sol. $H_2O$ | * |
| 1.348 | | 1.350 | 1.346 | *Bakerite* | Hal. | Two cleav. | G. = 2.96 | ** |
| | 1.406 | 1.406 | 1.391 | *Cryptohalite* | Hal. | 0001 ⊥ X | G. = 2.15 | 36 |
| | 1.432 | 1.435 | 1.427 | *Jarlite* | Hal. | X∧⊥100 = −16° | G. = 3.93. 2V = 79° | *** |
| 1.454 | | 1.491 | 1.445 | *Mercallite* | Sul. | ? | G. = 2.31 | *4 |
| 1.461 | | 1.474 | 1.461 | *Tincalconite* | Bor. | Rhom. | G. = 1.88 | 90 |
| 1.470 | | 1.484 | 1.461 | *Lapparentite* | Sul. | Mono. | 2V = 80° calc. | *5 |
| 1.482 | | 1.486 | 1.481 | *Ashtonite* | Sil. | 001, 110? | Fibrous | 432 |
| | 1.486 | 1.488 | 1.465 | *Burkeite* | Carb.-Sul. | X = c. Y = a | G. = 2.57 | *6 |
| 1.487 | | 1.540 | 1.470 | *Ammonioborite* | Bor. | Ext. Ang. = 10° ± | 2V = 60° ± 10° | 91 |
| | 1.488 | 1.504 | 1.47 ± | *Inderite* | Bor. | X = b. Z∧c = 5° | G. = 1.79 | *7 |
| | 1.489 | 1.489 | 1.486 | *Wischnewite* | Sil. | 10$\bar{1}$0. X = c | May show twinning | 30 |
| 1.492 | | 1.504 | 1.490 | *Lapparentite* | Sul. | Y = b. X∧c = −5° | 2V = 55° | *5 |
| | 1.495 | 1.497 | 1.445 | *Burkeite* | Carb.-Sul. | X = c. Y = a | No cleavage | *6 |
| | 1.500 | 1.586 | 1.380 | *Nahcolite* | Carb. | 101, 111 | X∧c = +27.5° | *8 |
| | 1.502 | 1.502 | 1.449 | *Ungemachite* | Sul. | 0001 ⊥ X | G. = 2.29 | *9 |
| | 1.506 | 1.529 | 1.423 | *Nesquehonite* | Carb. | 110. Y = c | G. = 1.85 | 84 |
| | 1.52 | 1.526 | 1.501 | *Letovicite* | Sul. | X∧c = 17½°. Z = b | G. = 1.81 | 97 |
| 1.524 | | 1.577 | 1.517 | *Ginorite* | Bor. | 010 ⊥ Y | 2V = 42°. X∧elong. = 51° | *10 |
| 1.530 | | 1.580 | 1.515 | *Earlandite* | Cit. | ? | 2V = 60° calc. G. = 1.95 | *11 |
| 1.534 | | 1.538 | 1.531 | *Minyulite* | Phos. | 110. X = c | G. = 2.45 | *12 |
| 1.536 | | 1.545 | 1.536 | *Ashcroftine* | Sil. | 100, 001 | G. = 2.61 | *13 |
| | 1.542 | 1.544 | 1.535 | *Foshallasite* | Sil. | X ⊥ cleav. | G. = 2.5 | *14 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.542 | | 1.542 | 1.489 | *Dakeite* | Sul.-Carb. | 001⊥X | G. = 2.51. Yellow: X<Y=Z | *15 |
| 1.543 | | 1.558 | 1.534 | *Gordonite* | Phos. | 010, 100 | Z ∧ c = −26° | 157 |
| 1.548 | ↑ | 1.548 | 1.518 | *Fluoborite* | Bor. | Hex. | G. = 2.9 | 92 |
| 1.553 | | 1.621 | 1.551 | *Veatchite* | Bor. | 010⊥Y | 2V = 37°. Z∧c = −38° | *16 |
| 1.553 | | 1.570 | 1.485 | *Alumohydrocalcite* | Carb. | 100, 010 | Ext. Ang. = 10° on fibers | 88 |
| 1.553 | | 1.557 | 1.535 | *Hydrocalumite* | Ox. | 001⊥X± | 2V = 24° | *17 |
| 1.556 | | 1.645 | 1.556 | *Julienite* | CSN+ | Tetrag. | G. = 1.65 | *18 |
| 1.558 | | 1.581 | 1.544 | *Louderbackite* | Sul. | Two good cleav. | G. = 2.19. Sol. in $H_2O$ | 116 |
| 1.566 | ↓ | 1.566 | 1.528 | *Fluoborite* | Bor. | Hex. | G. = 2.9 | 92 |

* G. Carobbi: *Mineral. Abst.*, V, 1933, p. 390.
** R. Bøgvad: *Med. Grönland*, CXIX, 1938, No. 7.
*** R. Bøgvad: *Med. Grönland*, XCII, 1933, No. 8.
*4 G. Carobbi: *Mineral. Abst.*, VI, 1935, p. 148.
*5 R. Rost: *Mineral. Abst.*, VII, 1938, p. 11; M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 740.
*6 W. F. Foshag: *Am. Mineral.*, XX, 1935, p. 50.
*7 Anna Boldyreva: *Mem. Soc. Russe Mineral.*, LXVI, 1937, p. 651.
*8 A. N. Winchell: Micro. Char. Art. Minerals, 2d Ed., New York, 1931, p. 199.
*9 M. A. Peacock, and M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 314.
*10 G. d'Achiardi: *Mineral. Abst.*, V, 1934, p. 484.
*11 F. A. Bannister and M. H. Hey: *Discovery Reports*, XIII, 1936, p. 60.
*12 E. S. Simpson and C. R. Le Mesurier: *Jour. Roy. Soc. W. Australia*, XIX, 1932, p. 13.
*13 M. H. Hey and F. A. Bannister: *Mineral. Mag.*, XXIII, 1933, p. 305.
*14 P. Tschirwinsky: *Mineral. Abst.*, VII, 1938, p. 10.
*15 E. S. Larsen and F. A. Gonyer: *Am. Mineral.*, XXII, 1937, p. 561.
*16 G. Switzer: *Am. Mineral.*, XXIII, 1938, p. 409
*17 C. E. Tilley: *Mineral Mag.*, XXIII, 1934, p. 607.
*18 A. Schoep and V. Billiet: *Zeit. Krist.*, XCI, 1935, p. 229.

SUPPLEMENTARY TABLE IV B.—REFRINGENCE OF ANISOTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ or $N_g$–$N_p$ | Mineral | Chem. | Cleavage, Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.570 | 1.574 | 1.559 | *Saléite* | Phos. | 001⊥X. 010 | 2V=61°. G.=3.1 | * |
| 1.572 | | 1.572 | 1.570 | *Englishite* | Phos. | 001⊥X | G.=2.65 | 158 |
| 1.575 | | 1.634 | 1.543 | *Metasideronatrite* | Sul. | 001, 010, 100 | Y=*b*; Z=*c*. Yellow: X<Y<Z | ** |
| | 1.575 | 1.575 | 1.547 | *Portlandite* | $Ca(OH)_2$ | 0001⊥X | G.=2.23 | *** |
| | 1.581 | 1.586 | 1.559 | *Skolite* | Sil. | 001⊥X± | 2V=0°–85° | *4 |
| | 1.581 | 1.581 | 1.565 | *Schuchardtite* | Sil. | 001⊥X | X=*bluish green*, Z=olive green | *5 |
| | 1.587 | 1.595 | 1.578 | *Leightonite* | Sul. | X∧*b*=3°–5° | G.=2.95 | *6 |
| 1.590 | | 1.599 | 1.590 | *Wardite* | Phos. | 001⊥Z | G.=2.81 | 158 |
| 1.590 | | 1.597 | 1.587 | *Bultfonteinite* | Sil. | 100 | Z′∧*c* on 010=28° | *7 |
| | 1.598 | 1.602 | 1.584 | *Millisite* | Phos. | X ‖ Elong. | G.=2.83 | 158 |
| | 1.600 | 1.600 | 1.586 | *Dehrnite* | Phos. | 0001⊥X | G.=3.0 | 151 |
| | 1.601 | 1.601 | 1.591 | *Dennisonite* | Phos. | 0001⊥X | G.=2.85 | 155 |
| | 1.605 | 1.607 | 1.601 | *Tuhualite* | Sil. | 001, 100, 010 | X=*a*. Y=*b* | *8 |
| 1.605 | | 1.613 | 1.600 | *Hydrophilite* | Hal. | 110 | Lam. twinning | 32 |
| 1.606 | | 1.621 | 1.597 | *Scawtite* | Sil. | Z∧*a*=29° | G.=2.77 | 442 |
| | 1.607 | 1.607 | 1.588 | *Schuchardtite* | Sil. | 001⊥X | X=*bluish green*, Z=olive green | *5 |
| | 1.614 | 1.631 | 1.600 | *Monetite* | Phos. | 001, 110 | G.=2.92 | 123 |
| | 1.615 | 1.629 | 1.600 | *Lehiite* | Phos. | Lg. Ext. Ang. | G.=2.89 | 158 |
| 1.622 | | 1.630 | 1.622 | *Garnierite* | Sil. | Z ‖ Elong. | 2V=0°–10° | *9 |
| 1.623 | | 1.663 | 1.591 | *Szomolnokite* | Sul. | X∧*c*=+26° | Y=*b*. G.=3.05 | *10 |
| | 1.623 | 1.624 | 1.613 | *Lewistonite* | Phos. | 0001⊥X | G.=3.06 | 151 |
| 1.630 | | 1.684 | 1.623 | *Guildite* | Sul. | 001, 100 | G.=2.72 | 117 |
| | 1.631 | 1.633 | 1.620 | *Parawollastonite* | Sil. | 100, $\bar{1}02$, 001 | Z∧*c*=−34° | *11 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.635 | 1.652 | 1.617 | *Tilleyite* | Sil. | 100. $X \wedge c = 18°$ | G. $\doteq$ 2.84 | *12 |
| 1.636 | 1.647 | 1.636 | *Woodhouseite* | Sul. | $0001 \perp Z$ | G. = 3.01 | *13 |
| 1.636 | 1.664 | 1.630 | *Hilgardite* | Bor. | $010 \perp Y$ | $Z \wedge c = 1.5°$. G. = 2.71 | *14 |
| 1.636 | 1.636 | 1.615 | *Mitscherlichite* | Hal. | $X = c$ | G. = 1.4 | 34 |
| 1.64± | 0.01± | | *Boehmite* | Ox. | $010 \perp Z$ | $110 \wedge 1\bar{1}0 = 63°$ | 46 |
| 1.641 | 1.647 | 1.640 | *Juanite* | Sil. | Z ‖ Elong. | Fibrous | *15 |
| 1.641 | 1.650 | 1.641 | *Deltaite* | Phos. | $Z = c$ | G. = 2.95 | 155 |
| 1.642 | 1.657 | 1.632 | *Collinsite* | Phos. | Four cleav. | G. = 2.95 | 128 |
| 1.642 | 1.646 | 1.575 | *β-Ascharite* | Bor. | X ‖ Elong. | G. = 2.65 | *16 |

* J. Thoreau and J. F. Vaes: *Bull. Soc. Belg. Geol.*, XLII, 1932, p. 96.

** M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 714.

*** C. E. Tilley: *Mineral. Mag.*, XXIII, 1933, p. 419.

*4 K. Smulikowski: *Am. Mineral.*, XXIII, 1938, p. 541.

*5 K. Spangenberg: *Zent. Mineral.*, 1938, A, p. 360.

*6 C. Palache: *Am. Mineral.*, XXIII, 1938, p. 34.

*7 J. Parry, A. F. Williams and F. E. Wright: *Mineral. Mag.*, XXIII, 1932, p. 145.

*8 P. Marshall: *Trans. Roy. Soc. N. Zealand*, LXV, 1936, p. 330.

*9 K. Spangenberg: *Zent. Mineral.*, 1938, A, p. 360.

*10 M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 714.

*11 M. A. Peacock: *Am. Jour. Sci.*, XXX, 1935, p. 495.

*12 E. S. Larsen and K. C. Dunham: *Am. Mineral.*, XVIII, 1933, p. 469.

*13 D. M. Lemmon: *Am. Mineral.*, XXII, 1937, p. 939.

*14 C. S. Hurlbut and R. E. Taylor: *Am. Mineral.*, XXII, 1937, p. 1052.

*15 E. S. Larsen and E. A. Goranson: *Am. Mineral.*, XVII, 1932, p. 343.

*16 M. N. Godlevsky: *Mem. Soc. Russe Mineral.*, LXVI, 1937, p. 315.

SUPPLEMENTARY TABLE IV B.—REFRINGENCE OF ANISOTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ or $N_g$–$N_p$ | Mineral | Chem. | Cleavage. Opt. Orient, | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | 1.643 | 1.657 | 1.553 | *Castanite* | Sul. | 010⊥X± | Y=yellow, Z=brownish red | 110 |
| 1.643 | | 1.695 | 1.631 | *Ransomite* | Sul. | Perf. cleav. | G.=2.63 | 116 |
| | 1.647 | 1.647 | 1.637 | *Aminoffite* | Sil. | 001⊥X | G.=2.94 | * |
| 1.648 | | 1.676 | 1.637 | *Loseyite* | Carb. | Y ‖ Elong. | 2V=64° | 84 |
| | 1.655 | 1.655 | 1.650 | *Ellestadite* | Sil. etc. | X ‖ Elong. | G.=3.07 | ** |
| | 1.660 | 1.663 | 1.648 | *Roweite* | Bor. | X=*a*; Y=*c* | 2V=15°. G.=2.92 | *** |
| 1.662 | | 1.663 | 1.662 | *Cahnite* | Arsen. | Tetrag. | G.=3.16 | 161 |
| | 1.663 | 1.665 | 1.640 | *Seamanite* | Phos. | Y=*b*; Z=*c* | G.=3.13 | 161 |
| | 1.663 | 1.737 | 1.598 | *Parabutlerite* | Sul. | Y=*c*; Z=*a* | X=yellow; Z=greenish yellow | *4 |
| 1.664 | | 1.688 | 1.660 | *Sérandite* | Sil. | 001, 100 | X∧*a*=−57° | 418 |
| | 1.667 | 1.667 | 1.655 | *Cuprosklodowskite* | Sil. | 001⊥Y | Gel. with HCl | *5 |
| | 1.674 | 1.731 | 1.604 | *Butlerite* | Sul. | 010 | X=brown-yellow, Z=canary yellow | 108 |
| 1.676 | | 1.683 | 1.672 | *Acrochordite* | Arsen. | Y∧*c*=40°–45° | X=*b*. G.=3.19 | 137 |
| 1.685 | | 1.745 | 1.646 | *Antofagastite* | Hal. | 110, 001 | 2V=75°. X=green, Z=blue | *6 |
| | 1.686 | 1.696 | 1.665 | *β-Uranotile* | Sil. | Z∧*c*=41° | Yellow; X<Y=Z | *7 |
| 1.690 | | 1.735 | 1.675 | *Legrandite* | Arsen. | Z∧*c*=−38° | X=*b*. G.=4.01 | 137 |
| | 1.692 | 1.692 | 1.640 | *Bandylite* | Bor. | 001⊥X | O=deep blue, E=yellow | *8 |
| 1.70± | | 1.73± | 1.70± | *Erikite* | Phos. | ? | G.=3.78 | *9 |
| | 1.7± | | 0.008 | *Tawmawite* | Sil. | 001, 100 | X=green, Y=yellow, Z=green | *10 |
| 1.704 | | 1.719 | 1.694 | *Roselite* | Phos. | 010⊥Y; X∧*a*=1° | Pink: X=Y>Z | 127 |
| 1.713 | | 1.724 | 1.708 | *Repossite* | Phos. | ? | G.=3.74 | *11 |
| 1.715 | | 1.730 | 1.707 | *Larnite* | Sil. | X∧*c*=13° | Z=*b* | 194 |
| 1.718 | | 1.734 | 1.709 | *Metahohmanite* | Sul. | ? | X=yellow; Z=brown | *12 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.719 | | | 1.738 | 1.710 | *Johannsenite* | Sil. | 110 | $Z \wedge c = 48°$ | *13 |
| 1.719 | | | 1.733 | 1.719 | *Bromellite* | Ox. | $10\bar{1}0$ | G. = 3.02 | *14 |
| | 1.725 | | 1.748 | 1.687 | *Bermanite* | Phos. | $001 \perp X$ | X = red, Y = yellow, Z = red | *15 |
| 1.728 | | ↓ | 1.735 | 1.725 | *Roselite* | Phos. | $010 \perp X$ | $Y \wedge a = 12°–20°$ | *16 |
| | 1.728 | | 1.735 | 1.720 | *Landesite* | Phos. | $010 \perp Z$ | X = **brown,** Y = *brown*, Z = yellow | 156 |
| | 1.728 | | 1.732 | 1.720 | *Varulite* | Phos. | 001, 010 | Y = *b*. G = 3.58 | *17 |
| 1.732 | | | 1.805 | 1.714 | *Lopezite* | Chrom. | 010, 100, 001 | Sol. in $H_2O$ | *18 |
| | 1.734 | | 1.736 | 1.723 | *Gageite* | Sil. | Z ‖ elong. | G. = 3.58 | *19 |
| | 1.736 | | 1.739 | 1.715 | *Renardite* | Phos. | $001 \perp X$ | Y = *c*; G. = 4.+ | 148 |

* C. S. Hurlbut: *Geol. För. Förh. Stockholm*, LIX, 1937, p. 290.
** D. McConnell: *Am. Mineral.*, XXII, 1937, p. 977.
*** H. Berman and F. A. Gonyer: *Am. Mineral.*, XXII, 1937, p. 301.
*4 M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 714.
*5 R. Nováček: *Mineral. Abst.*, VI, 1935, p. 149.
*6 C. Palache and W. F. Foshag: *Am. Mineral.*, XXIII, 1938, p. 85.
*7 R. Nováček: *Mineral. Abst.*, VI, 1935, p. 148.
*8 C. Palache and W. F. Foshag: *Am. Mineral.*, XXIII, 1938, p. 85.
*9 V. I. Gerassimovsky: *Trans. Lomonossov Inst. Geochem. Cryst. Mineral.*, X, 1937, p. 5.
*10 P. Eskola: *C. R. Soc. Géol. Finlande*, VII, 1933, p. 26.
*11 E. Grill: *Am. Mineral.*, XX, 1935, p. 740.
*12 M. C. Bandy: *Am. Mineral.*, XXIII, 1938, p. 714.
*13 W. T. Schaller: *Am. Mineral.*, XXIII, 1938, p. 575.
*14 G. Aminoff: *Zeit. Krist.*, LXII, 1925, p. 113.
*15 C. S. Hurlbut: *Am. Mineral.*, XXI, 1936, p. 656.
*16 M. A. Peacock: *Am. Mineral.*, XXI, 1936, p. 589.
*17 P. Quensel: *Geol. För. Förh. Stockholm*, LIX, 1937, p. 93. Optic sign from personal communication, Nov. 16, 1938.
*18 M. C. Bandy: *Am. Mineral.*, XXII, 1937, p. 929.
*19 C. Palache: *U. S. Geol. Surv. Prof. P.* 180, 1935, p. 111.

SUPPLEMENTARY TABLE IV B.—REFRINGENCE OF ANISOTROPIC MINERALS—*continued*

| $N_o$ or $N_m$ + | $N_o$ or $N_m$ − | $N_g$ | $N_p$ (or $N_g-N_p$) | Mineral | Chem. | Cleavage, Opt. Orient. | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| 1.749 | | 1.749 | 1.724 | *Allodelphite* | Sil. | ? | Brown | 440 |
| 1.750 | | 1.752 | 1.750 | *Abukumalite* | Phos. | Poor cleav. | G.=4.35 | * |
| 1.751 | | 1.761 | 1.750 | *Synadelphite* | Arsen. | X∧c=45° | Brown: X=Y<Z | 155 |
| | 1.76 | 1.76 | 1.72 | *β-Uranopilite* | Sul. | Y ‖ Elong. | 2V=Sm. | ** |
| 1.763 | | 1.783 | 1.759 | *Austinite* | Arsen. | 110; Z=b | Y=a  G.=4.12 | *** |
| 1.764 | | 1.794 | 1.763 | *Clinoferrosilite* | Sil. | 110 | Z∧c=35° | *4 |
| 1.765± | | 1.775 | 1.760 | *Alluaudite* | Phos. | Z⊥best cl. | G.=3.58 | *5 |
| | 1.765 | 1.839 | 1.735 | *Murmanite* | Sil. | 001⊥X± | X=pink; Y=brown; Z=**brown** | *6 |
| 1.767 | | 1.823 | 1.748 | *Joaquinite* | Sil. | Y=b; Z=c | G.=5.80 | 417 |
| | 1.769 | 1.769 | 1.760 | *Ca-Larsenite* | Sil. | ? | G.=4.42 | 187 |
| 1.770 | | 1.840 | 1.710 | *Rossite* | Van. | 010 | G.=2.45 | 158 |
| | 1.775 | 1.777 | 1.772 | *Britholite* | Sil. | X=c; Y=a | Ps. Hex. | 441 |
| 1.78± | | 1.80± | ? | *Vandenbrandeite* | Uran. | 001, 110 | G.=4.96. Abn. interf. col. | *7 |
| | 1.78± | | 0.035 | *Taosite* | Ox. | ? | X=yellow.  Z=red-brown | *8 |
| | 1.780 | 1.792 | 1.756 | *Alleghanyite* | Sil. | X∧a=−35° | G.=4.02 | *9 |
| | 1.80 | 1.80 | 1.75 | *Ammoniojarosite* | Sul. | 0001⊥X | Soluble in HCl | 114 |
| | 1.810 | 1.816 | 1.787 | *Arsenoclasite* | Arsen. | 010; X=b | Y=a.  G.=4.16 | 133 |
| 1.864 | | 1.894 | 1.851 | *Plumbosynadelphite* | Arsen. | ? | Brown.  X<Y<Z | *10 |
| 1.89 | | 1.90 | 1.88 | *Dumontite* | Phos. | Y=c; Z=a | Yellow: X<Y | 148 |
| | 1.90 | 1.92 | 1.674 | *Ianthinite* | Ox. | 100⊥X | Y=c | 60 |
| | 1.902 | 1.908 | 1.870 | *Talasskite* | Sil. | 001⊥Y | X=b | *11 |
| | 1.905 | 1.910 | 1.873 | *Yeatmanite* | Sil. | 100⊥X± | G.=4.8 | *12 |
| | 1.905 | 1.905 | 1.785 | *Argentojarosite* | Sul. | 0001⊥X | Yellow: O>E | 114 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.930 | 1.939 | 1.886 | *Fersmanite* | Tit. | $Y=b$. $X\perp 001\pm$ | Brown. G.=3.44 | 168 |
| 1.95 | 1.96 | 1.92 | *Larsenite* | Sil. | $X=a$; $Y=c$. | G.=5.9 | 187 |
| 2.002 | 2.02 | 1.93 | *Lindgrenite* | Molyb. | $010\perp Z$ | 2V=71°. G.=4.26 | *13 |
| 2.06 | 2.08 | 2.03 | *Duftite* | Arsen. | Orth.? | G.=6.19 | 132 |
| 2.07 | 2.12 | ? | *Curite* | Uran. | $Z=c$ | G.=7.19 | 103 |
| 2.098 | 2.108 | 1.997 | *Clarkeite* | Uran. | ? | 2V=40°±. G.=6.39 | 111 |
| 2.222 | 2.224 | 2.186 | *Fervanite* | Van. | Incl. Ext. | 2V=Sm. | 142 |

* S. Hata: *Sci. Pap. Inst. Phys. Chem. Res. Tokyo*, XXXIV, 1938, p. 1018.
** R. Nováček: *N. Jahrb. Mineral.*, 1936, I, p. 141.
*** L. W. Staples: *Am. Mineral.*, XX, 1935, p. 112.
*4 N. L. Bowen: *Am. Jour. Sci.*, XXX, 1935, p. 481.
*5 P. Quensel: *Geol. För. Förh. Stockholm*, LIX, 1937, p. 77.
*6 N. N. Gutkova: *Mineral. Abst.*, V, 1933, p. 198.
*7 A. Schoep: *N. Jahrb. Mineral.*, 1933, I, p. 250.
*8 J. de Lapparent: *Comp. Rend.*, CCI, 1935, p. 154.
*9 A. F. Rogers: *Am. Mineral.*, XX, 1935, p. 25.
*10 C. S. Hurlbut: *Am. Mineral.*, XXII, 1937, p. 526.
*11 V. D. Nikitin: *Mineral. Abst.*, VI, 1937, p. 438.
*12 C. Palache, L. H. Bauer and H. Berman: *Mineral. Abst.*, VII, 1938, p. 14.
*13 C. Palache: *Am. Mineral.*, XX, 1935, p. 484.

# TABLE V.—DISPERSION OF MINERALS

The new methods of studying powdered minerals lead naturally, not only to a knowledge of their indices of refraction in ordinary light, but also and simultaneously to a knowledge of the variation in their indices with variation in the wave-length (or color) of light; that is, the new methods lead to a knowledge of the dispersion of the minerals. Of course the dispersion of a mineral is as definite a physical property as its refringence or birefringence and may therefore be used to identify it. At present, data regarding the dispersion of minerals are remarkably scanty and in some cases not very accurate.

The dispersion given is always the difference between the index in light of 4861 Å wave-length (= the Frauenhofer line *F* or the $\beta$ line of hydrogen) and the index in light of 6563 Å wave-length (= the Frauenhofer line *C* or the $\alpha$ line of hydrogen). In the tables this dispersion is meant by the expression *F–C*.

In anisotropic crystals the dispersion of the substance is, in general, not the same for light vibrating in directions which are crystallographically unlike. Therefore the dispersion for $N_g$ is not the same as for $N_p$, and the dispersion for $N_m$ is not equal to that for $N_g$ nor to that for $N_p$. However, these differences are usually small, and the only dispersion given in the table is that for N of isotropic substances, $N_o$ of uniaxial substances and $N_m$ of biaxial substances.

In the literature [1] the dispersion is very rarely given directly and the indices measured for different wave-lengths do not always include the wave-lengths of the *F* and *C* lines here used as standards. Therefore it has been necessary to obtain the dispersion given in the table by calculation or graphic solution in many cases. In cases in which this involves notable extrapolation the result is given as a ± value and the extrapolation involved is indicated in footnotes.

In the following table minerals are classified first on the basis of their dispersion, and in each group thus established they are arranged

[1] For references to the literature see A. N. Winchell: Dispersion of Minerals, *Am. Mineral*, XIV, 1929, p. 125.

in the order of increasing refringence. This table is remarkably incomplete even though it includes all available data.

For methods of measuring the index of refraction with different wave-lengths of light and thus obtaining the dispersion, see Part I, pages 228–239 and 244–248.

For methods of estimating or measuring the birefringence of minerals, see Part I, pages 119–123, 136–138, and 244–246.

For methods of determining the optic sign, see Part I, pages 129–135, 138, 148–152, 169, 206–213, and 228–239.

For methods of estimating or measuring the optic axial angle, see Part I, pages 186–189, 210, 226–227, and 239–244.

For a discussion of cleavage in minerals, see Part I, pages 29–32.

For a list of abbreviations and symbols, see page xiii.

## TABLE V.—DISPERSION OF MINERALS

| N, $N_o$ or $N_m$ F−C | N, $N_o$ or $N_m$ D | $N_g-N_p$ | Mineral | Chem. | Sign | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | Section 1. $N_F-N_C$=.000 to .0075 | | | | | |
| .0062 | 1.309 | .004 | **Ice** | $H_2O$ | + | 0° | Index extremely low | 40 |
| .0039 | 1.328 | Very weak | *Villiaumite* | NaF | − | 0° | Red. Sol. hot $H_2O$ | 30 |
| .004±[a] | 1.340 | .000 | *Cryolithionite* | Hal. | .. | ....... | 110 cleav. | 34 |
| .0045 | 1.434 | .000 | Fluorite | $CaF_2$ | .. | ....... | 111 cleav. Tinted ± | 31 |
| .0049 | 1.443 | .000 | *Yttrofluorite* | Hal. | .. | ....... | Poor cleav. Rare | 35 |
| .007 | 1.462 | .015 | *Picromerite* | Sul. | + | 48° | 20$\bar{1}$ cleav. Sol. $H_2O$ | 112 |
| .006±[b] | 1.503 | .009 | *Prosopite* | Hal. | + | 63° | 211 cleav. Rare | 34 |
| .006 | 1.509 | .023 | *Nocerite* | Hal. | − | 0° | Hex. 0001 cleav. | 38 |
| .0065±[c] | 1.535 | .000 | *Langbeinite* | Sul. | .. | ....... | Sol. $H_2O$ | 110 |
| .005±[d] | 1.546 | .006 | *Eudidymite* | Sil. | + | 30° | Lam. twin. | 418 |
| .007±[e] | 1.581 | .027 | Scapolite | Sil. | − | 0° | 100 cleav. Tet. | 293 |
| .006±[f] | 1.622 | .025 | **Tremolite** | Sil. | − | 82° | 110 cleav. at 56° | 245 |
| | | | Section 2. $N_F-N_C$=.0075 to .0085 | | | | | |
| .0079 | 1.455 | .028 | Epsomite | Sul. | − | 51° | 010 cleav. H.=2 | 103 |
| .0081 | 1.469 | .025 | Borax | Bor. | − | 40° | 100 cleav. Sol. $H_2O$ | 90 |
| .0081 | 1.472 | .009 | *Boussingaultite* | Sul. | + | 51° | 20$\bar{1}$ cleav. Sol. $H_2O$ | 113 |
| .0084 | 1.48 | .031 | *Goslarite* | Sul. | − | 46° | 010 cleav. Sol. $H_2O$ | 104 |
| .008±[g] | 1.489 | .025 | *Morenosite* | Sul. | − | 42° | 010 cleav. Sol. $H_2O$ | 103 |
| .008 | 1.508 | .000± | **LEUCITE** | Sil. | + | Sm. | Trapezohedrons | 291 |
| .008 | 1.509 | .071 | *Pirssonite* | Carb. | + | 33° | No cleav. Efferv. HCl | 87 |
| .008±[h] | 1.512 | .019 | *Flagstaffite* | H, C, O | + | 77° | Sol. alcohol | 301 |
| .008 | 1.518 | .025 | Cancrinite | Sil. | − | 0° | 10$\bar{1}$0 cleav. | 301 |
| .0079 | 1.523 | .009 | Gypsum | Sul. | + | 58° | 010 cleav. H.=2 | 104 |
| .008 | 1.523 | .006 | **ADULARIA** | Sil. | − | 70°± | 001, 010 cleav. | 361 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| .008 | 1.53 | .01 | **ALBITE** | Sil. | + | 75°± | 001, 010 cleav. | 369 |
| .0084 | 1.537 | .004 | **NEPHELITE** | Sil. | − | 0° | Gel. HCl | 298 |
| .0084 | 1.537 | .01± | **Cordierite** | Sil. | − | 60°± | Ps. Hex. twin | 307 |
| .0083 | 1.543 | .008 | **OLIGOCLASE** | Sil. | ± | 90°± | 001, 010 cleav. | 371 |
| .0078 | 1.544 | .009 | **QUARTZ** | $SiO_2$ | + | 0° | No cleav. Insol. | 54 |
| .008± [i] | 1.544 | .002 | *Epididymite* | Sil. | + | 23° | 001, 010 cleav. Ps. Hex. | 418 |
| .0084 | 1.549 | .015 | *Edingtonite* | Sil. | − | 50° | 110 cleav. Gel. HCl | 389 |
| .008 | 1.554 | .016 | *Grothine* | Sil. | + | Mod. | $X=b$; $Y=c$ | 432 |
| .008± [h] | 1.558 | .010 | *Beryllonite* | Phos. | − | 68° | 001, 100 cleav. | 149 |
| .0078 | 1.575 | .044 | Anhydrite | $CaSO_4$ | + | 42° | 001, 010, 100 cleav. | 98 |
| .008 | 1.593 | .013 | **Celsian** | Sil. | + | 80°± | 001, 010 cleav. | 359 |
| .008± [j] | 1.599 | .04± | **MUSCOVITE** | Sil. | − | 40°± | 001 cleav. | 267 |
| .0078 | 1.618 | .01 | Topaz | Sil. | + | 60°± | 001 cleav. H.=8 | 198 |
| .0084 | 1.623 | .009 | Celestite | $SrSO_4$ | + | 51° | 001, 110, 010 cleav. | 99 |
| .008± [k] | 1.635 | .021 | **ANTHOPHYLLITE** | Sil. | − | 88°± | 110 cleav. at 55° | 240 |
| .008± [l] | 1.65± | .005± | **Melilite** | Sil. | − | 0° | Tet. Gel. HCl | 208 |
| .008± [m] | 1.66± | .03± | *Eosphorite* | Phos. | − | 40° | 100 cleav. Sol. HCl | 156 |

Section 3. $N_F - N_C = .0085$ to $.0095$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| .009 [b] | 1.478 | .015 | *Melanterite* | Sul. | + | 82° | Sol. $H_2O$ | 106 |
| .009± [n] | 1.479 | .012 | Natrolite | Sil. | + | 62° | 110 cleav. Acic. | 390 |
| .009± [o] | 1.483 | .000 | **Sodalite** | Sil. | .. | ....... | Poor cleav. Gel. HCl | 289 |
| .0091 | 1.52 | .025 | Cancrinite | Sil. | − | 0° | 10$\bar{1}$0 cleav. | 301 |
| .009± [p] | 1.525 | .000 | *Pollucite* | Sil. | .. | ....... | Contains Cs | 293 |

[a] From Tl–Li=.0026.
[b] From "blue"+"red".
[c] From $N_{Li}=1.5281$, $N_{Tl}=1.5343$
[d] From Tl−red=.0032.
[e] From Tl–Li=.0047. [f] From Tl–Li=.004.
[g] From F–D=.0061.
[h] From Tl–Li=.0055.
[i] From "green"−"red"=.0049.
[j] From Tl–Li=.0064.
[k] From "blue"−"red"=.008.
[l] From Na–"red"=.0027.
[m] From Tl–Li=.0059 for $N_g$ and .0052 for $N_p$.
[n] From Tl–Li=.0054.
[o] From Tl–Li=.0059.
[p] From Tl–Li=.0058.

TABLE V.—DISPERSION OF MINERALS—*Continued*

| N, $N_o$ or $N_m$ F−C | N, $N_o$ or $N_m$ D | $N_g-N_p$ | Mineral | Chem. | Sign | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | Section 3. $N_F-N_C$=.0085 to .0095—*Continued* | | | | | |
| .009± [a] | 1.528± | .006 | **ANORTHOCLASE** | Sil. | − | 50°± | 001, 010 cleav. | 366 |
| .0089 | 1.535 | .002± | Apophyllite | Sil. | ± | 0° | Abn. int. colors | 262 |
| .0087 | 1.538± | .004 | **NEPHELITE** | Sil. | − | 0° | Gel. HCl | 298 |
| .009± [b] | 1.54 | .017 | *Gismondite* | Sil. | − | 84° | Gel. HCl | 373 |
| .009± | 1.55 | .01± | **Cordierite** | Sil. | − | Lg. | Ps. Hex. twin. | 307 |
| .0086 | 1.553± | .007 | **ANDESINE** | Sil. | ± | 90°± | 001, 010 cleav. | 372 |
| .0087 | 1.558 | .010 | *Beryllonite* | Phos. | − | 68° | 001, 100 cleav. | 149 |
| .009 | 1.562± | .008 | **LABRADORITE** | Sil. | + | 80°± | 001, 010 cleav. | 374 |
| .009 [c] | 1.572± | .006 | Beryl | Sil. | − | 0° | Colorless or tinted | 212 |
| .0093 | 1.572± | .009 | **BYTOWNITE** | Sil. | − | 85°± | 001, 010 cleav. | 376 |
| .0095 | 1.58± | .012 | **ANORTHITE** | Sil. | − | 77° | 001, 010 cleav. | 378 |
| .009 | 1.586 | .074 | *Hambergite* | Bor. | + | 87° | 010, 100 cleav. | 91 |
| .009± [d] | 1.587± | .03± | Scapolite | Sil. | − | 0° | 100 cleav. Tet. | 293 |
| .009 | 1.592 | .028 | *Colemanite* | Bor. | + | 55° | 010 cleav. Sol. HCl | 93 |
| .0094 | 1.602 | .000 | *Zunyite* | Sil. | .. | ....... | 111 cleav. Insol. | 414 |
| .009 | 1.637 | .012 | Barite | $BaSO_4$ | + | 37° | 001, 110 cleav. | 100 |
| .009 | 1.645± | .025± | **Tourmaline** | Sil. | − | 0° | Max. absorp. ⊥$c$ | 301 |
| .009 | 1.654 | .016 | Phenakite | Sil. | + | 0° | $11\bar{2}0$ cleav. | 185 |
| .009 | 1.655 | .015 | *Euclase* | Sil. | + | 50° | 010 cleav. | 432 |
| .009± [e] | 1.66 | .02± | **Sillimanite** | Sil. | + | 30°± | 010 cleav. Acic. | 200 |
| | | | Section 4. $N_F-N_C$=.0095 to .0105 | | | | | |
| .010± [f] | 1.484 | .000 | **Sodalite** | Sil. | .. | ....... | Poor cleav. Gel. HCl | 289 |
| .010± [g] | 1.510 | .012 | *Petalite* | Sil. | + | 84° | 001 cleav. | 309 |
| .01± [h] | 1.514 | .000 | *Northupite* | Carb. | .. | ....... | No cleav. Efferv. HCl | 85 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| .010± [i] | 1.572± | .005± | Beryl | Sil. | − | 0°. | Tinted ± | 212 |
| .0095 | 1.58± | .012 | **ANORTHITE** | Sil. | − | 80°± | 001, 010 cleav. | 378 |
| .01± [j] | 1.587± | .04 | **MUSCOVITE** | Sil. | − | 40°± | 001 cleav. | 267 |
| .010 | 1.592 | .028 | Colemanite | Bor. | + | 55° | 010 cleav. Sol. HCl | 93 |
| .010± [k] | 1.617 | .022 | Hemimorphite | Sil. | + | 46° | 110 cleav. Gel. HCl | 211 |
| .01± [l] | 1.634 | .006 | *Danburite* | Sil. | − | 87° | Poor cleav. Disp. | 210 |
| .010± | 1.638± | .004 | **Apatite** | Phos. | − | 0° | Hex. Prism. | 129 |
| .01± | 1.64± | .025± | **Tourmaline** | Sil. | − | 0° | Max. absorp. $\perp c$ | 301 |
| .01± [m] | 1.658 | .02± | **Sillimanite** | Sil. | + | 30°± | 010 cleav. Acic. | 200 |
| .010± [n] | 1.665 | .015 | Spodumene | Sil. | + | 60°± | 110 cleav. at 87° | 236 |
| .010 | 1.672 | .099 | *Parisite* | Carb. | + | 0° | 0001 cleav. Efferv. HCl | 85 |
| .01± [o] | 1.722 | .048 | Diaspore | Ox. | + | 84° | Y $\perp$ 010 cleav | 46 |
| .01± [o] | 1.72± | .000 | Spinel | $MgAl_2O_4$ | .. | ....... | Oct. H.=8 | 62 |
| .01± [p] | 1.729 | .025 | *Ganophyllite* | Sil. | − | 24° | 001 cleav. | 436 |

Section 5. $N_F - N_C$ = .0105 to .0115

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| .011 | 1.490 | .000 | Sylvite | KCl | .. | ....... | Sol. $H_2O$ | 30 |
| .011± [q] | 1.522 | .007 | **MICROCLINE** | Sil. | − | 83° | 001, 010 cleav. | 364 |
| .0115 | 1.566 | .02± | Brucite | $Mg(OH)_2$ | + | 0° | 0001 cleav. | 42 |
| .011± | 1.575± | .006± | Beryl | Sil. | − | 0° | Colorless or tinted | 212 |
| .0113± [r] | 1.590 | .035± | Scapolite | Sil. | − | 0° | Tet. | 293 |
| .011 | 1.645± | .025± | **Tourmaline** | Sil. | − | 0° | Max. absorp. $\perp c$ | 301 |
| .0106 | 1.678 | .028 | **DIOPSIDE** | Sil. | + | 59° | 110 cleav. at 87° | 224 |

[a] From Na–Li = .003.
[b] From Tl–Li = .0061.
[c] From Cd-green–Li = .0074.
[d] From Tl–Li = .0063.
[e] From Tl–Li = .0068
[f] From Tl–Li = .0061.
[g] From "blue"–"red" = .010.
[h] From Tl–Li = .0063.
[i] From E–B = .0068.
[j] From Tl–Li = .0071.
[k] From Tl–Li = .006.
[l] From Tl–Li = .0063.
[m] From Tl–Li = .0069.
[n] From Tl–Li = .0063.
[o] From "blue"–"red" = .010.
[p] From Na–Li = .0037.
[q] From Tl–Li = .0063.
[r] From Tl–Li = .0068.

TABLE V.—DISPERSION OF MINERALS—*Continued*

| N, $N_o$ or $N_m$ F−C | N, $N_o$ or $N_m$ D | $N_g-N_p$ | Mineral | Chem. | Sign | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | Section 5. $N_F-N_C$=.0105 to .0115—*Continued* | | | | | |
| .0114 | 1.722 | .012 | **Kyanite** | $Al_2SiO_5$ | − | 82° | 100, 010 cleav. | 205 |
| .011± [a] | 1.747 | .009 | *Chrysoberyl* | $BeAl_2O_4$ | + | 65°± | H.=8.5. G.=3.64 | 65 |
| .0106 | 1.77 | .008 | Corundum | $Al_2O_3$ | − | 0° | H.=9. G.=4.1 | 43 |
| .011± [b] | 1.814 | .000 | **Spessartite** | Sil. | .. | ....... | H.=7. G.=4±. Insol. | 178 |
| | | | Section 6. $N_F-N_C$=.0115 to .0125 | | | | | |
| .012± [c] | 1.534 | .027 | Wavellite | Phos. | + | 72° | 101, 010 cleav. | 144 |
| .012± [d] | 1.539 | .028 | *Mellite* | Al, C, O, H | − | 0° | Yellow±. Tet. | 88 |
| .0115 | 1.564 | .02 | Brucite | $Mg(OH)_2$ | + | 0° | 0001 cleav. | 42 |
| .012± [e] | 1.570± | .006 | Beryl | Sil. | − | 0° | Colorless or tinted | 212 |
| .012± | 1.59± | .010± | **Clinochlore** | Sil. | + | 0°± | 001 cleav. | 283 |
| .012± [f] | 1.595 | .027 | *Leucophane* | Sil. | − | 39° | 001, 100, 010 cleav. | 210 |
| .012± [g] | 1.613 | .019 | *Meliphanite* | Sil. | − | 0° | 001 cleav. Tet. | 210 |
| .0123 | 1.639 | .004 | **Akermanite** | Sil. | + | 0° | 110 cleav. Tet. | 209 |
| .012± [g] | 1.652 | .025± | **Tourmaline** | Sil. | − | 0° | Max. absorp. ⊥ elong. | 301 |
| .0117± [c] | 1.66 | .02± | **Sillimanite** | Sil. | + | 30°± | 010 cleav. Acic. | 200 |
| .012± [h] | 1.662 | .017 | Monticellite | Sil. | − | 75° | Poor cleav. Gel. HCl | 187 |
| .012± | 1.667 | .011 | *Boracite* | Bor. | + | 83° | Ps. Isom. twin. | 94 |
| .0123 | 1.681 | .155 | **Aragonite** | $CaCO_3$ | − | 18° | Ps. Hex. twin. | 79 |
| .012± [i] | 1.682 | .035 | *Pyrosmalite* | Sil. | − | 0° | 0001 cleav. Gel. HCl | 408 |
| .012± [i] | 1.688 | .004 | Triphylite | Phos. | + | 0°± | 001, 010 cleav. Gel. HCl | 149 |
| .012± [j] | 1.694 | .002 | *Rhodizite* | Bor. | ? | ? | Ps. Isom. Insol. | 94 |
| .0124 | 1.713± | .039 | **Olivine** | Sil. | + | 84°± | Poor cleav. Gel. HCl | 189 |
| .012± [k] | 1.719 | .000 | Spinel | $MgAl_2O_4$ | .. | ....... | Oct. H.=8 | 62 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| .0125± [l] | 1.744± | .000 | **Pyrope** (pure) | Sil. | .. | ....... | G.=3.5. Insol. | 178 |
| .0125 | 1.745 | .012 | **Staurolite** | Sil. | + | 85°± | 010 cleav. Golden | 202 |
| .012± | 1.763± | .050± | **EPIDOTE** | Sil. | − | 70°± | 001 cleav. Golden | 314 |
| | | | Section 7. $N_F-N_C$=.0125 to .0135 | | | | | |
| .013± [m] | 1.474 | .021 | *Thenardite* | Sul. | + | 83° | 001 cleav. Sol. $H_2O$ | 96 |
| .0127 | 1.544 | .000 | Halite | NaCl | .. | ....... | 100 cleav. Sol. $H_2O$ | 29 |
| .013± | 1.570± | .021 | **Scapolite** | Sil. | − | 0° | Tet. | 293 |
| .0127 [n] | 1.582 | .006 | Beryl | Sil. | − | 0° | Colorless or tinted | 212 |
| .013± [m] | 1.59± | .010 | **Clinochlore** | Sil. | + | 0°± | 001 cleav. Mono. | 283 |
| .013± [m] | 1.651 | .035 | **Forsterite** | Sil. | + | 85° | Poor cleav. Gel. HCl | 188 |
| .0134 | 1.658 | .172 | **CALCITE** | $CaCO_3$ | − | 0° | $10\bar{1}1$ cleav. Efferv. HCl | 71 |
| .013 [o] | 1.644 | .053 | Dioptase | Sil. | + | 0° | $10\bar{1}1$ cleav. Gel. HCl | 186 |
| .0132 | 1.672 | .011 | *Hardystonite* | Sil. | − | 0° | 001 cleav. Gel. HCl | 209 |
| .0133 | 1.679 | .177 | **DOLOMITE** | Carb. | − | 0° | $10\bar{1}1$ cleav. Efferv. HCl | 73 |
| .0127 | 1.681 | .155 | **Aragonite** | $CaCO_3$ | − | 18° | Ps. Hex. twin. | 79 |
| .0127 | 1.682 | .000± | *Thorite* | $ThSiO_4$ | + | 0° | 110 cleav. Tet. | 185 |
| .013± [m] | 1.685± | .010 | **Axinite** | Sil. | − | 75°± | Wedge shape. Pleo. | 425 |
| .0132 | 1.701± | .04± | **OLIVINE** | Sil. | − | 85°± | Poor cleav. Gel. HCl | 189 |
| .0132 | 1.704± | .025± | **AUGITE** | Sil. | + | 61° | 110 cleav. at 87° | 228 |
| .0127 | 1.717± | .005 | **Clinozoisite** | Sil. | + | 64° | 001 cleav. | 312 |
| .013 | 1.738 | .000 | *Periclase* | MgO | .. | ....... | 100 cleav. Sol. HCl | 41 |
| .013 | 1 74± | .000 | **Grossularite** | Sil. | .. | ....... | G.=3.5. Insol. | 180 |
| .013± [p] | 1.745± | .000 | **Pyrope** | Sil. | .. | ....... | G.=3.5. Insol. | 178 |

[a] From Tl–Li=.0072.
[b] From Tl–Li=.0084.
[c] From "blue"–"red"=.012
[d] From E–B=.009.
[e] From E–B=.0084.
[f] From Na–Li=.004.
[g] From Tl–Li=.0064.
[h] From Tl–Li=.0059.
[i] From Tl–Li=.008.
[j] From Tl–Li=.007.
[k] From Tl–Li=.0074.
[l] From Tl–Li=.0086.
[m] From "blue"–"red"=.013.
[n] From E–B=.0086.
[o] From F–D=.0126.
[p] From Tl–Li=.009±.

TABLE V.—DISPERSION OF MINERALS—*Continued*

| N, $N_o$ or $N_m$ | | $N_g-N_p$ | Mineral | Chem. | Sign | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| F−C | D | | | | | | | |
| | | | Section 7. $N_F-N_C$=.0125 to .0135—*Continued* | | | | | |
| .0127 | 1.75± | .012 | **Staurolite** | Sil. | + | 85°± | 010 cleav. Golden | 202 |
| .013± [a] | 1.793 | .053 | *Thortveitite* | Sil. | − | 66° | 110 cleav. Green | 211 |
| .013± [b] | 1.804± | .000 | **Spessartite** | Sil. | .. | ....... | G.=4.2. Insol. | 178 |
| | | | Section 8. $N_F-N_C$=.0135 to .0155 | | | | | |
| .0138 [c] | 1.555 | .160 | *Whewellite* | Oxal. | + | 84° | 001, 010 cleav. Organic | 89 |
| .014± [d] | 1.60± | .05± | Vivianite | Phos. | + | 85°± | 010 cleav. Blue-green | 126 |
| .014± [e] | 1.654 | .025 | Tourmaline | Sil. | − | 0° | Max. absorp. $\perp c$ | 301 |
| .0136 | 1.658 | .172 | **CALCITE** | $CaCO_3$ | − | 0° | $10\bar{1}1$ cleav. Efferv. HCl | 71 |
| .014± [f] | 1.658 | .015 | **HORNBLENDE** | Sil. | − | 80°± | 110 cleav. at 56° | 247 |
| .014± [g] | 1.668 | .016 | *Rinkite* | Sil. | + | 43° | 100 cleav. Yellow | 423 |
| .0137 | 1.670 | .013 | *Justite* | Sil. | − | 0° | Tet. Gel. HCl | 209 |
| .0142 | 1.672 | .011 | *Hardystonite* | Sil. | − | 0° | Tet. Gel. HCl | 209 |
| .014± [h] | 1.685± | .010 | **Axinite** | Sil. | − | 75°± | Wedge-shaped. Pleo. | 425 |
| .014± [i] | 1.692 | .18± | **DOLOMITE** | Carb. | − | 0° | $10\bar{1}1$ cleav. Efferv. HCl | 73 |
| .0145 | 1.717± | .005± | **Clinozoisite** | Sil. | + | 70°± | 001 cleav. | 312 |
| .015± [j] | 1.721 | .095 | Xenotime | Phos. | + | 0° | 110 cleav. Tet. | 138 |
| .014± [k] | 1.726 | .023 | **PYROXENE** | Sil. | + | 60°± | 110 cleav. at 87° | 213 |
| .014 | 1.737 | .000 | *Periclase* | MgO | .. | ....... | 100 cleav. Sol. HCl | 41 |
| .014± [l] | 1.745 | .000 | **Pyrope** | Sil. | .. | ....... | G.=3.5. Insol. | 178 |
| .014± | 1.745 | .000 | **Grossularite** | Sil. | .. | ....... | G.=3.5. Insol. | 180 |
| .015± [m] | 1.80± | .000 | **Almandite** | Sil. | .. | ....... | G.=4.25. Insol. | 178 |
| .015 ± [n] | 1.815± | .000 | **Spessartite** | Sil. | .. | ....... | G.=4.2. Insol. | 178 |

Section 9. $N_F - N_C = .0155$ to $.0195$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| .0187 | 1.505 | .171 | Niter | $KNO_3$ | − | 7°. | 011 cleav. Sol. $H_2O$ | 89 |
| .018 | 1.54± | .06± | *Copiapite* | Sul. | + | 60°± | 001 cleav. Yellow | 108 |
| .019± | 1.550. | .102 | *Rhomboclase* | Sul. | + | Sm. | 001 cleav. Red | 108 |
| .019 | 1.585 | .248 | *Nitratite* | $NaNO_3$ | − | 0° | 10$\bar{1}$1 cleav. Sol. $H_2O$ | 89 |
| .016± [o] | 1.589 | .001 | *Rinneite* | Hal. | + | 0° | Abn. int. colors | 33 |
| .0167 | 1.642 | .000 | *Salammoniac* | $NH_4Cl$ | .. | ....... | Poor cleav. Sol. $H_2O$ | 30 |
| .017± [p] | 1.653 | .045 | Datolite | Sil. | − | 74° | No cleav. Gel. HCl | 424 |
| .016 | 1.694 | .029 | Willemite | Sil. | + | 0° | 0001 cleav. Gel. HCl | 186 |
| .017± [q] | 1.720 | .011 | *Trimerite* | Sil. | − | 83° | 001 cleav. Sol. HCl | 401 |
| .016± [r] | 1.737 | .019 | **Hedenbergite** | Sil. | + | 60° | 110 cleav. at 87° | 224 |
| .016–.018± | 1.74± | .03± | **EPIDOTE** | Sil. | − | 80°± | 001 cleav. Golden | 314 |
| .016± [s] | 1.745 | .087 | *Libethenite* | Phos. | − | 83°± | Poor cleav. Green | 132 |
| .016± [t] | 1.746 | .000 | **Pyrope** | Sil. | .. | ....... | G.=3.5. Insol. | 178 |
| .017± [u] | 1.76± | .000 | **Grossularite** | Sil. | .. | ....... | G.=3.5. Insol. | 180 |
| .0165 | 1.79± | .05± | Monazite | Phos. | + | 12°± | 001 cleav. Yellow | 138 |
| .019± [v] | 1.811 | .000 | **Spessartite** | Sil. | .. | ....... | G.=4.2. Insol. | 178 |
| .017 | 1.849 | .228 | Smithsonite | Carb. | − | 0° | 10$\bar{1}$1 cleav. | 78 |
| .018± [w] | 1.866 | .091 | *Caledonite* | Sul. | − | 85° | 001 cleav. Blue-green | 120 |

Section 10. $N_F - N_C = .0195$ to $.0245$

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| .022± [x] | 1.624 | .002 | *Metatorbernite* | Phos. | + | 0°± | Abn. int. colors | 145 |
| .02± [y] | 1.716 | .026 | *Woehlerite* | Sil. | − | 75°± | 010 cleav. Yellow | 441 |

[a] From Tl–Li = .0094.
[b] From Tl–Li = .0097.
[c] From Tl–Li = .0086.
[d] From "violet"–"red" = .014.
[e] From Tl–Li = .0085.
[f] From F–C = .015 for $N_g$ and .0138 for $N_p$ as measured by V. E. Barnes at the University of Wisconsin, 1929.
[g] From Tl–Li = .010.
[h] From "blue"–"red" = .0139.
[i] From Tl–Li = .0093.
[j] From Tl–Li = .0078.
[k] From Tl–C = .0085.
[l] From Tl–Li = .0083.
[m] From Tl–Li = .010.
[n] From Tl–Li = .0105.
[o] From Tl–Li = .0094.
[p] From Tl–Li = .0085.
[q] From Tl–Li = .0081.
[r] From Tl–Li = .0092.
[s] From "blue"–"red" = .016.
[t] From Tl–red = .0071.
[u] From Tl–Li = .0097.
[v] From Tl–Li = .0108.
[w] From "blue"–"red" = .018.
[x] From Bowen's graph.
[y] From "blue"–"red" = .02

TABLE V.—DISPERSION OF MINERALS—*Continued*

| N, $N_o$ or $N_m$ F—C | N, $N_o$ or $N_m$ D | $N_g-N_p$ | Mineral | Chem. | Sign | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| | | | Section 10. $N_F-N_C$=.0195 to .0245—*Continued* | | | | | |
| .022± [a] | 1.742 | .000 | **Garnet** | Sil. | .. | ....... | Insol. | 174 |
| .02± [b] | 1.755 | .000 | *Arsenolite* | $As_2O_3$ | .. | ....... | Oct., Mass. | 43 |
| .0204 | 1.786 | .026 | *Allactite* | Phos. | − | 4° | X=green; Y, Z=yellow | 155 |
| .021± [c] | 1.786 | .038 | Tephroite | Sil. | − | 65° | Pleo. Gel. HCl | 194 |
| .02± [d] | 1.807 | .000 | *Gahnite* | $ZnAl_2O_4$ | .. | ....... | Octahedral | 63 |
| .021 [e] | 1.838 | .000 | *Uvarovite* | Sil. | .. | ....... | Insol. | 180 |
| .023± [f] | 1.875 | .242 | **Siderite** | $FeCO_3$ | − | 0° | $10\bar{1}1$ cleav. Efferv. HCl | 76 |
| .022± [c] | 1.909 | .083 | **Titanite** | Sil. | + | 26° | Wedge cryst. Extr. Disp. | 204 |
| .021 | 1.92 | .016 | Scheelite | $CaWO_4$ | + | 0° | 111 cleav. | 97 |
| .023 | 1.93± | .05± | **Zircon** | $ZrSiO_4$ | + | 0° | Tet. prisms. G.=4.7 | 183 |
| | | | Section 11. $N_F-N_C$=.0245 to .0295 | | | | | |
| .029 | 1.652 | .017 | Mullite | Sil. | + | 50°± | 010 cleav. Pink | 201 |
| .027± [g] | 1.664 | .150 | Strontianite | $SrCO_3$ | − | 11° | 110 cleav. Efferv. HCl | 81 |
| .028± | 1.75± | .04± | Epidote | Sil. | − | 75°± | 001 cleav. Golden | 314 |
| .027± [h] | 1.76± | .000 | **Grossularite** | Sil. | .. | ....... | Insol. | 180 |
| .027 | 1.812 | .000 | *Beckelite* | Sil. | .. | ....... | 100 cleav. Yellow | 420 |
| .029 | 1.84± | .000 | *Roméite* | Antim. | .. | ....... | 111 cleav. Yellow | 159 |
| .026 | 1.883 | .017 | Anglesite | $PbSO_4$ | + | 70°± | 001, 010 cleav. G.=6.3 | 99 |
| .025 | 2.42 | .000 | Diamond | C | .. | ....... | 111 cleav. H.=10 | 13 |
| | | | Section 12. $N_F-N_C$=.0295 to .0495 | | | | | |
| .03± [i] | 1.75 | .045 | *Lorenzenite* | Sil. | + | 39° | 120 cleav. Rare | 400 |
| .035± [j] | 1.799 | .05 | **Acmite** | Sil. | − | 62° | 110 cleav. at 87° | 234 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| .04± [k] | 1.89± | .000 | **Andradite** | Sil. | .. | ....... | Insol. | 180 |
| .033± [l] | 1.90± | .09± | **Titanite** | Sil. | + | 33°± | Wedge cryst. Extr. Disp. | 204 |
| .04± [m] | 1.97 | .011 | *Powellite* | $CaMoO_4$ | + | 0° | 111 cleav. Tet. | 98 |
| .049 | 1.99± • | .096 | Cassiterite | $SnO_2$ | + | 0° | 110 cleav. G.=7± | 52 |
| .049 | 2.06 | .000 | *Chlorargyrite* | AgCl | .. | ....... | H.=1.5. G.=5.5 | 30 |
| .046 | 2.06 | .012 | Pyromorphite | Phos. | − | 0° | Hex. Sol. $HNO_3$ | 131 |
| .035± [n] | 2.074 | .273 | Cerussite | Carb. | − | 9° | 110 cleav. G.=6.5 | 80 |
| .04± [o] | 2.087 | .000 | *Senarmontite* | $Sb_2O_3$ | .. | ....... | Oct. Sol. HCl | 43 |
| .045± [p] | 2.16 Li | .000 | *Manganosite* | MnO | .. | ....... | 100 cleav. Green | 41 |

Section 13. $N_F-N_C$=.0495 to .0995

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| .066 | 1.82 | .09 | *Carphosiderite* | Sul. | − | 0° | 0001 cleav. Sol. HCl | 107 |
| .057± | 1.97 | .683 | *Calomel* | $Hg_2Cl_2$ | + | 0° | 100 cleav. Tet. | 30 |
| .053 [q] | 2.00 | .000 | *Pyrochlore* | Colum. | .. | ....... | Oct. Brown± | 163 |
| .08 | 2.013 | .016 | Zincite | ZnO | + | 0° | 0001 cleav. Red± | 41 |
| .07± [r] | 2.038 | .287 | Sulfur | S | + | 69° | G.=2. Yellow± | 14 |
| .05 | 2.06 | .000 | *Chlorargyrite* | AgCl | .. | ....... | H.=1.5. G.=5.5 | 30 |
| .08 | 2.25 | .000 | *Bromyrite* | AgBr | .. | ....... | H.=1.5. G.=6.0 | 30 |
| .091 | 2.295 | .010 | *Finnemanite* | Arsen. | − | 0° | $10\bar{1}1$ cleav. G.=7.2 | 159 |
| .08± [s] | 2.356 | .022 | *Wurtzite* | ZnS | + | 0° | Fibrous. Pleo. | 20 |
| .09 | 2.368± | .000 | Sphalerite | ZnS | .. | .... | 110 cleav. Sol. HCl | 19 |
| .09± [t] | 2.41± | .08± | *Stibiotantalite* | Tant. | + | 75° | 100 cleav. G.=7 | 167 |
| .073 | 2.654 | .043 | *Moissanite* | SiC | + | 0° | H.=9.5. G.=3.2 | 17 |

[a] From Tl–Li=.0145.
[b] From Na–Li=.007.
[c] From Tl–Li=.014.
[d] From "green"–"yellow"=.0126.
[e] From Tl–Li=.013.
[f] From Tl–Li=.0156.
[g] From Tl–Li=.015.
[h] From Tl–Li=.0101.
[i] From Na–Li=.009 for $N_g$ and .011 for $N_p$.
[j] From Tl–"red"=.0167.
[k] From Tl–Li=.024.
[l] From Tl–Li=.022.
[m] From 1.959 for 667$\mu\mu$ and 1.982 for 533$\mu\mu$.
[n] From E–B=.03.
[o] From Na–Li=.014.
[p] From "green"–"red"=.03.
[q] From Tl–Li=.035.
[r] From Tl–Li=.042.
[s] From Na–Li=.026.
[t] From Tl–Li=.059

TABLE V.—DISPERSION OF MINERALS—*Continued*

| N, $N_o$ or $N_m$ | | $N_g-N_p$ | Mineral | Chem. | Sign | 2V | Other Characters | Page |
|---|---|---|---|---|---|---|---|---|
| F—C | D | | | | | | | |
| | | | Section 14. $N_F-N_C$=.0995 to .195 | | | | | |
| .125 | 2.21 | .01 | *Iodyrite* | AgI | + | 0° | 0001 cleav. G.=5.6 | 30 |
| .12± [a] | 2.30 | .000 | *Brannerite* | Ox. | .. | ....... | Ps. Tet. G.=5± | 69 |
| .13± [b] | 2.35 | .000 | *Marshite* | CuI | .. | ....... | 110 cleav. G.=5.6 | 30 |
| .13± [c] | 2.39 | .14± | **Goethite** | Ox. | − | Sm. | 010 cleav. Extr. Disp. | 47 |
| .134 | 2.41± | .098 | Wulfenite | $PbMoO_4$ | − | 0° | 111 cleav. G.=6.9 | 98 |
| .12± [a] | 2.481 | .271 | *Pyrophanite* | $MnTiO_3$ | − | 0° | $02\bar{2}1$ cleav. Red± | 67 |
| .142 | 2.56 | .073 | *Octahedrite* | $TiO_2$ | − | 0° | 001 cleav. Pleo. | 53 |
| .13± [c] | 2.59 | .14± | *Brookite* | $TiO_2$ | + | Sm. | Poor cleav. Brown | 59 |
| .158± [d] | 2.60± | .286 | **Rutile** | $TiO_2$ | + | 0° | Acic. G.=4.2 | 50 |
| | | | Section 15. $N_F-N_C$>.195 | | | | | |
| .21± [e] | 2.23 | .000 | *Bunsenite* | NiO | .. | ....... | Oct. Green | 41 |
| .23± [f] | 2.47± | .000 | Sphalerite | (Zn, Fe)S | .. | ....... | 110 cleav. Brown | 19 |
| .23± [g] | 2.51 | .023 | *Greenockite* | CdS | + | 0° | G.=4.8. Yellow | 21 |
| .55± [h] | 2.84 | Str. | *Tenorite* | CuO | − | ? | Nearly opaque | 41 |
| .4± [i] | 2.91 | 36 | Cinnabar | HgS | + | 0° | $10\bar{1}0$ cleav. Red | 21 |
| .33± [j] | 3 087 | .295 | *Proustite* | $Ag_3AsS_3$ | − | 0° | $10\bar{1}1$ cleav. Scarlet | 27 |
| .34± [k] | 3 176 | .110 | *Hutchinsonite* | Tl, As, S | − | 38° | 100 cleav. Scarlet | 28 |
| .5± [l] | 3 22 | .28 | **HEMATITE** | $Fe_2O_3$ | − | 0° | Red to opaque | **44** |

[a] From Na-Li=.04.
[b] From Tl-Li=.072.
[c] From Na-Li=.044.
[d] From Tl-Li=.105.
[e] From "blue"-"red"=.21.
[f] From Na-Li=.075.
[g] From "green"-"red"=.136.
[h] From "blue"-"red"=.55.
[i] From $599\mu\mu-762\mu\mu$=.149.
[j] From Na-Li=.109.
[k] From D-C=.113.
[l] From D-C=.178.

## EXPLANATION OF PLATES

PLATE I.—The colored diagram shows the relation between interference colors of crystals, the thickness of the sections and the birefringence of the crystals. The interference colors begin with darkness at the left for zero birefringence and continue through gray, white, yellow and red to the end of the first order. The second order begins with blue and continues through green and yellow to end with the second red. The third order is similar to the second order, but the colors are somewhat paler. In the fourth order the colors are still paler, and the diagram does not go beyond the fourth order because the colors in higher orders are too pale to be of much use. The vertical coordinate on the diagram gives the thickness of the section, from zero to 0.06 millimeter. The birefringence ($N_g - N_p$) is given by the figures along the top and right side of the colored portion, and these should be used with the diagonal lines across the diagram. The interference color produced by a section of any crystal depends upon the birefringence ($N_g - N_p$) of the crystal, the thickness of the section, and the direction in which the section is cut with respect to the optic axis or optic axes of the crystal. In using the diagram to determine a mineral in a thin section it is desirable to use the following procedure:

1. Determine the thickness of the section (unless it can be safely assumed to be of standard thickness, namely 0.03 mm.) by finding the highest interference color given by some known mineral such as quartz or feldspar; if quartz, with $N_g - N_p = 0.009$, gives pure white as its highest interference color, it is easy to find from the diagram that the intersection of pure white with the diagonal line for $N_g - N_p = 0.009$ is at a point indicating a thickness (on the horizontal line) of about 0.03 mm.

2. Find the highest interference color given by the unknown mineral, taking care to note the order of the colors observed (see Part I, pages 112 and 116 to 119).

3. Find the point where this highest interference color intersects the line for the measured thickness; from this point follow the diag-

onal line to the top or right side, where the birefringence of the mineral will be found, as well as the names of important minerals having that birefringence.

In using the diagram it should be remembered that only rock-forming minerals and a few others are given along the border; when studying ores, etc., the diagram will give the birefringence. but will not always give the name of the mineral.

Furthermore, the diagram is based on the assumption that all minerals have the same birefringence for light of all wave-lengths; this is only approximately true for most minerals. Therefore, slight differences of tint are to be expected between the colors of the diagram and the colors observed. It is only in very rare cases that these differences are sufficient to interfere with the use of the diagram.

Many minerals vary in composition and therefore vary in birefringence; in general, minerals are entered on the diagram as many times as necessary to express all variations in their birefringence.

Plate II.—In Plate II the most important minerals are arranged on the basis of their refringence, birefringence and optic sign. The horizontal coordinate is the refringence (N, $N_o$ or $N_m$) with a change of scale at 1.85 and a range from 1.45 to 2.45. The vertical coordinate is birefringence ($N_g - N_p$) with zero birefringence in the middle of the diagram, birefringence of positive minerals from zero to 0.060 in the upper half and birefringence of negative minerals from zero to 0.060 in the lower half of the diagram.

Nearly all minerals vary in composition and therefore vary in refringence and birefringence, and, in some cases, in optic sign. All known variations in refringence and birefringence (and sign) are shown on the diagram, and this results in the condition that most minerals are represented not by points, nor even lines, but by areas. When data are sufficiently abundant and accurate the lines of the diagram are drawn as curves, as illustrated in the case of plagioclase (birefringence $= \pm 0.01 \pm$ and refringence $= 1.53$ to $1.58$) and of scapolite (birefringence $= -0.02 \pm$ and refringence $= 1.56 \pm$) but in most cases data are scanty and not highly accurate—then the lines are straight. In some cases—notably in the case of ordinary hornblende (birefringence $= -0.02 \pm$ and refringence $= 1.65 \pm$)—available accurate data do not represent the limits of variation, and the area shown will be enlarged when accurate data are at hand.

When minerals vary in optic sign by passing through zero birefringence, the condition is easily shown by means of a line crossing

zero birefringence as illustrated by scapolite (birefringence $= -0.02\pm$ and refringence $= 1.56\pm$) or by means of an area crossing zero birefringence, as illustrated by chlorite (birefringence $= +0.015$ to $-0.01$ and refringence $= 1.55$ to $1.67$). When minerals vary in sign by means of having the optic angle (2V) pass through 90°, the condition is not so easily shown on the diagram, but it is indicated by the change of full lines to dash lines in the case of plagioclase (shown both in the positive and the negative fields at birefringence $= 0.01\pm$ and refringence $= 1.53$ to $1.58$) or by a full line continued by an arrow with the appropriate sign; then the continuation of the line can be found in the field of opposite sign; this condition is illustrated by the case of olivine at birefringence $= 0.036$ and refringence $= 1.65$ to $1.68$ in the positive field and at refringence $= 1.68+$ and birefringence $= 0.037$ in the negative field.

The diagram permits one to find very readily all the indices of refraction of any mineral. If the mineral is isotropic, its position along the middle line (zero birefringence) gives its only index, N. The name of every anisotropic mineral on the diagram is followed by a number which gives the value of the true optic angle (2V) in degrees. If a mineral is uniaxial the name is followed by 0°; its position on the diagram gives the value of $N_o$ and the optic sign; if the mineral is positive $N_o$ is also $N_p$ and $N_g$ may be obtained by adding the birefringence to the value of $N_p$. If the mineral is negative $N_o$ is also $N_g$ and $N_p$ may be obtained by subtracting the birefringence from the value of $N_g$. Finally, if the mineral is biaxial, its position on the diagram is determined by $N_m$ and $N_g - N_p$ and the other indices ($N_g$ and $N_p$) may be obtained readily from its optic sign, birefringence and optic angle by the use of the small diagram in the lower right hand corner of the main diagram. This small diagram has the true optic angle (2V) as the vertical coordinate, and, as the horizontal coordinate, it has $K = \frac{B_a}{N_g - N_p}$ and $K' = \frac{B_o}{N_g - N_p}$, in which $B_a$ = the birefringence of the acute bisectrix section and $B_o$ = the birefringence of the obtuse bisectrix section. For positive minerals, $K = \frac{N_m - N_p}{N_g - N_p}$ and $K' = \frac{N_g - N_m}{N_g - N_p}$ and, for positive minerals K' is the (decimal) fraction of the birefringence ($N_g - N_p$) which must be added to $N_m$ in order to obtain $N_g$ and K is the (decimal) fraction of the birefringence which must be subtracted from $N_m$ to obtain $N_p$; for negative minerals K' is the

(decimal) fraction of the birefringence which must be subtracted from $N_m$ in order to obtain $N_p$ and $K$ is the (decimal) fraction of the birefringence which must be added to $N_m$ in order to obtain $N_g$. Accordingly, K′ gives the decimal fraction of the birefringence to be added to or subtracted from $N_m$, *as suggested by the optic sign,* to obtain another index, and K gives the decimal fraction of the birefringence to be added to or subtracted from $N_m$, *contrary to the suggestion of the optic sign* to obtain the third index. For example, from the main diagram anhydrite is positive with $2V=42°$, $N_m=1.576$ and $N_g-N_p=0.044$; from the small diagram for $2V=42°$, $K'=0.87$ and $K=0.13$; accordingly, $N_g=1.576+.044\times0.87=1.614$ and $N_p=1.576-.044\times0.13=1.570$. These are the correct values of $N_g$ and $N_p$.

In using this diagram to determine minerals it is desirable, first, to determine the optic sign, second, to measure the birefringence, and, third, to estimate the refringence. For the estimation of the refringence any section may be used if the birefringence of the mineral is weak, but a section showing the lowest interference color should be used if the birefringence of the mineral is not weak. Then, by making a small allowance for error in the measurement of the birefringence and a larger allowance for error in estimating the refringence, an area may be outlined on the diagram in which the unknown mineral will be found, if it is a rock-forming mineral. One reason why it is worth while to be able to obtain the other indices of refraction from the diagram is that they give the possible range of refringence which the mineral may show.

PLATE III.—The stereographic plot of Wulff is a device for plotting and measuring angles in a stereographic projection. It is printed on translucent paper so as to permit the reproduction from it of as many white prints as may be desired for use in the study of the optic properties of feldspars and in the study of any biaxial minerals by the methods of the universal stage.

# INDEX

C

D

## I



## J

T

U



V

*For explanation of plates, see page 213.*